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Effects of Hunting Regulation Changes on Elk and Hunters in the Gravelly-Snowcrest Mountains, Montana

Kenneth L. Hamlin and Michael S. Ross

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Effects of Hunting Regulation Changes on Elk and Hunters in the Gravelly-Snowcrest Mountains, Montana

By

Kenneth L. Hamlin and Michael S. Ross

Montana Fish, Wildlife and Parks
Wildlife Division
Helena, Montana

Federal Aid Project W-120-R-

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Montana Fish,
Wildlife & Parks

FOREWORD

Rocky Mountain elk are one of the most important big game species in Montana and people of all persuasions are passionate about this valuable resource. Factors that influence elk hunting, elk habitat, and the population dynamics of various elk herds, are the focus of spirited debate and scientific question. No where is this more evident than in Southwestern Montana, which represents some of the most productive elk habitat within the state and the nation, and provides approximately half of the statewide elk harvest and hunter opportunity.

It was against this backdrop that questions arose in the early 1980s regarding calf elk recruitment rates and hunting season frameworks for bull elk. In certain hunting districts, especially those with low to moderate levels of security, wildlife managers observed low calf:cow ratios and low bull:cow ratios during post-hunting season winter surveys. They were concerned that the first parameter, low productivity, was potentially a function of the latter. Local sportsmen's groups and concerned individuals were asking similar questions and were likewise pressing for changes to any-antlered bull hunting seasons.

Beginning in 1984, Montana Fish, Wildlife and Parks initiated the Gravelly-Snowcrest Elk Research Study to address key aspects of this issue. An extensive sample of marked cow and bull elk (599 radio collars and 342 neck collars) provided the foundation for this research effort. Intensive monitoring via ground and aerial surveys were employed to document changes in important elk population parameters. Check stations, the statewide harvest survey and targeted mail questionnaires were utilized to collect data on hunter participation rates and attitudes in addition to specific elk harvest information. This long-term research effort, spanning 12 years of field investigations, followed by several years of intensive analysis, has culminated in this report. This effort was funded by state hunter license dollars in combination with the Federal Aid in Wildife Restoration program.

The results contained herein provide important insights into the dynamics of this elk herd, including population numbers, sex and age structure, reproduction and mortality, distribution and movements, and broad habitat use patterns. In addition, the authors evaluated the impacts of several hunting season modifications on bull elk age structure, progressing from an any-bull legal season to a branch-antlered bull season to a brow-tined bull season type. Outcomes are compared to results from other areas of Montana where different harvest management prescriptions have been implemented. Population trend, rate of growth, and productivity were monitored under varying levels of antlerless elk harvest and implications for future population management options are discussed. It is our intent that these research findings be incorporated into elk management discussions at all levels and assist in refining elk management strategies across the state.

Donald A. Childress
Donald A. Childress
Administrator, Wildlife Division

Jeffrey T. Herbert
Supervisor, Research & Technical Services

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MFWP (continued):
Jim DeBoer
Rich DeSimone
Gary Dusek
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Montana – 1910

Dedicated to the hunters, landowners, employees of the Montana Fish and Game Department, and others who worked to preserve elk and expand elk habitat and distribution after 1910.

A CENTURY OF CONSERVATION
1901 2001
Montana Fish,
Wildlife & Parks

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EXECUTIVE SUMMARY

Chapters 1, 2, and 3 give the background, setting, and methods for this study of elk in the Gravelly-Snowcrest Mountains of southwestern Montana, which was conducted during 1984-1996. We present results and description of information on physical characteristics, population numbers, sex and age structure, reproduction and mortality, distribution and movements, and habitat use of elk as well as information on hunting regulations, hunter numbers, and hunter characteristics in Chapters 4 through 10. In Chapters 11 and 12, we synthesize results to describe effects of hunting regulations on elk population characteristics, hunter characteristics and opinions, and present the implications of these findings to elk management in Montana.

We present here a brief synopsis of our findings. For a more detailed presentation of our findings and recommendations, we suggest that the reader with limited time should read Chapters 11 – Effect of Hunting Regulations and Chapter 12 – Management Implications. For the reader with more time and interest, or for those who want to access specific background information for findings and recommendations, Chapters 4 – 10 provide specific information by subject area.

1) Total bull:100 cow ratios increased during periods of both branch-antlered bull and brow-tined bull regulations compared to antlered bull regulations in the low security habitat of the Gravelly-Snowcrest Mountains. However, brow-tined bull:100 cow ratios were lower under branch-antlered bull regulations than compared to antlered bull regulations. Brow-tined bull:100 cow ratios were about the same for antlered bull and brow-tined bull regulations. There was substantial annual variation in bull:100 cow ratios, regardless of regulation type and numbers of hunters. Early cold and snowy weather increased hunting success, reducing post-season bull:100 cow ratios. Mild weather during hunting season resulted in lower hunting success and higher post-season bull:100 cow ratios. Although weather had a major influence on bull survival during the hunting season, a general increasing trend of bull:100 cow ratios throughout the study indicated that branch-antlered bull and especially brow-tined bull regulations resulted in slowly increasing bull:100 cow ratios in this area of low security habitat.

2) By regulation definition, average age of harvested bulls increased during branch-antlered and brow-tined bull regulations compared to the antlered bull regulation. These regulations did not result in a lower harvest rate for legally defined bulls, only a reduction in the number of bulls defined to be legal to harvest. Thus these regulation changes delayed mortality and increased average age of harvested bulls by one year. Based on check station data, average age of harvested bulls ≥2 years old did not increase under brow-tined bull compared to branch-antlered bull regulations. However antler point data from the Statewide Harvest Questionnaire indicated a minor increase in age of harvested bulls for brow-tined bull regulations compared to branch-antlered bull regulations. For Gallatin-Madison hunting districts, with more secure habitat conditions than for the Gravelly-Snowcrest hunting districts, the data indicated a lower average age of harvested bulls ≥2 years old with branch-antlered

and brow-tined bull regulations compared to the antlered bull regulation. Branch-antlered and brow-tined bull regulations apparently placed increasing pressure on bulls ≥2 years old, reducing their survival and reducing average age in areas of habitat security with older bulls.

3) We did not find evidence that increasing post-season bull:100 cow ratios in a range from 3 - 21:100 or brow-tined bull:100 cow ratios in a range from 0.6 - 5:100 resulted in increased calf:100 cow ratios. Calf:100 cow ratios in the Gravelly-Snowcrest hunting districts were higher than in other areas with much higher bull:100 cow and brow-tined bull:100 cow ratios. Major changes in calf:100 cow ratios and differences among areas appeared to be primarily related to factors other than numbers and ages of breeding bulls. This study started too late to answer the question of why calf:100 cow ratios were unusually low during 1980 and 1981. However, calf:100 cow ratios improved before increased numbers of ≥2-year-old breeding bulls could have affected calf production and survival. Low calf:100 cow ratios during 1980 and 1981 may have been related to conditions during winter 1978 - 1979, which was the most severe during the period 1968 - 1998.

4) Both regulation types with antler point restrictions resulted in illegal mortality. We estimated that illegal mortality of yearling bulls was 25 - 35% under branch-antlered bull regulations. Additionally, legal harvest of about 75% of branch-antlered yearlings occurred. This resulted in estimated total annual mortality of 40% for yearling males. For the brow-tined bull regulation, estimated total annual mortality of yearling bulls was 15.5%. Most (14.4%) was illegal harvest. We could find no evidence that harvesting branch-antlered yearlings and protection of spike-antlered yearling bulls under the branch-antlered bull regulation resulted in smaller antlered older bulls.

5) Our data suggested that wounding loss, especially of antlerless elk, may be higher than many realize. To account for wounding loss of adult females in population modeling for the Gravelly-Snowcrest Mountains, we were required to multiply the kill reported on the Statewide Harvest Questionnaire by 0.20 - 0.24. For bulls, wounding loss was 0.10 times the kill reported on the Statewide Harvest Questionnaire.

6) Our data indicated that with calf recruitment averaging about 45 calves:100 cows, the elk population continued to grow despite harvest rates for cows averaging 15 - 20%. Harvest rate and population growth rate varied among population segments, however. Annual harvest rate of adult bulls averaged 75%. Because we observed little natural mortality during the study period, this elk population could sustain harvest rates exceeding that of many deer populations.

7) At this time, the brow-tined bull regulation provides substantial hunter harvest, recreation, and hunter satisfaction for the Gravelly-Snowcrest area, especially as part of a diverse statewide package of opportunities. The desire of most hunters and MFWP at this time is to produce maximum recreation and harvest of meat from this

area. That objective is being achieved well, perhaps better than anywhere in Montana on a per unit of area basis. For some areas of low security habitat with high hunting mortality of bulls, the brow-tined bull regulation is a reasonable compromise to increase numbers of 2- and 3-year-old bulls while maintaining hunter opportunity. However, we do not recommend branch-antlered or brow-tined bull regulations for areas of secure habitat and where bull age structure is adequate. Should production of trophy bulls ever become an objective for Gravelly-Snowcrest hunting districts, it will be achieved only by limited entry hunting. A temporary 50% decline in hunter numbers following introduction of the branch-antlered bull regulation did not increase bull survival. Therefore, a substantial reduction in hunter opportunity (perhaps 85%, 6,500-7,000 bull hunters) would be necessary to manage this area for "trophy bulls".

8) Because of the wide areas over which bulls move, bull management must be on a landscape scale, including the entire Gravelly-Snowcrest area and parts of Idaho and Wyoming. Although certain aspects of antlerless management could be at the landscape scale, the more discrete herd ranges of cow elk lend themselves to herd range/hunting district level management. This level of management is certainly necessary to reduce some wintering populations while at the same time increasing or stabilizing other wintering populations within the Gravelly-Snowcrest area. The numbers of antlerless permits issued recently appears to have passed the point of efficiency at current population levels. Some form of general either-sex hunting or a quota regulation may be necessary to reduce the elk population to levels where antlerless permits are effective.

9) Aerial trend counts appeared to accurately represent population trend over time periods ≥5 years. Further, total population estimates derived from these trend counts seemed to be relatively accurate because they reconciled with mortality estimates from telemetry, sex and age classifications, corrected age structures, and harvest estimates. Annual changes in elk numbers counted may not be reliable, but reasonable management decisions can be made based on trend counts over several years.

10) For purposes of bull elk management, no timber harvests are justified in the Gravelly-Snowcrest Mountains. Here, cover during the hunting season is limited, not forage. Our data clearly showed that locations of living elk during the hunting season were disproportionately in mature timber stands distant from roads compared to locations of elk kill sites. All mature timber types were important to elk for hiding cover during the hunting season. Thus, the most commercially important stands for logging were most necessary to elk for hiding cover.

11) Responses to our hunter questionnaires indicated that most unsolicited hunter comments were about issues dealing with roads, access, and ATVs. Hunters were relatively evenly split on these issues, some wanting more and some less roads, access, and use by ATVs. This is not an easy issue to address because goals for harvest of bulls and antlerless elk differ. Increased access, in whatever form, could increase the harvest rate of bulls, which is undesirable. Conversely, increased access might increase antlerless harvest, which is desirable at current population levels.

Restriction of use of ATVs and snowmobiles to game retrieval only and during certain hours only may be an option worth considering.

12) We believe that allantoin:creatinine ratios from elk snow-urine samples may have potential to index nutritional status of elk during winter. However, we found that hematological parameters and diastema lengths had little value as sensitive indicators of condition for this elk population.

13) Other condition indicators (antler characteristics, weights, pregnancy rates, and urinary metabolite ratios) indicated that elk in the Gravelly-Snowcrest area were in good physical condition relative to other elk populations.

14) Movement patterns of the elk indicated that substantial genetic interchange occurred among the Gravelly-Snowcrest elk population and adjacent Montana, Idaho, and Wyoming elk populations.

CHAPTER 1

INTRODUCTION

From lows in about 1910, elk (*Cervus elaphus nelsoni*) populations in Montana recovered through the present, assisted by closed hunting seasons in the early to mid 1900s and a trapping and transplanting program. Acquisition of land for winter range by the Montana Fish and Game Department that began in 1940 also contributed substantially to increases in elk populations (Hamlin 1993). Through the 1940s, the major hunted elk herds in Montana occupied the Gallatin, Sun River, and Flathead drainages (West 1941). By the late 1940s, increases in existing elk populations and re-establishment of populations in other areas had resulted in opening additional areas for hunting and less restrictive hunting regulations.

In the late 1950s through the mid-1970s, biologists desired reductions in elk numbers in some areas and less restrictive regulations were implemented (Rognrud and Janson 1971). In 1963, 67% of Montana's hunted elk habitat was open to season-long (approximately 5-week) either-sex hunting.

After the mid-1970s, season-long either-sex hunting was severely reduced and occurred in only 1% of elk habitat by 1985. Either-sex elk hunting was replaced in most areas by a regulation where any-antlered bull (AB) was legal, with antlerless harvest regulated by permits issued through drawings (limited entry, LE). Montana Department Fish, Wildlife and Parks (MFWP) directed elk management in Montana during the 1980s primarily toward increasing elk numbers and maintaining a diversity of choice in hunting opportunity. Diversity of choice was maintained by a diversity of regulations among hunting units (Wildlife Division, MFWP 1985, Youmans, H. 1992).

The AB regulation remained widespread, but an increasing number of hunting districts (HDs) were restricted to branch-antlered bull (BAB) hunting. In 1981, only one hunting district (HD 324) restricted bull harvest to BAB. By 1985, seven hunting districts (HDs 320, 322, 323, 324, 326, 330, 333) had BAB regulations and two were BAB after an either-sex quota was reached (HDs 424, 442). In 1989, 28 hunting districts (most in southwestern Montana) and portions of 2 others had BAB regulations.

Depending on the area, the BAB regulation resulted from concerns over low calf:100 cow ratios, low post-season bull:100 cow ratios, the possible long-term biological effects of yearling bulls siring most of the calves, or from the desire of some hunters to harvest a larger bull. MFWP cautioned hunters that few bulls older than 2- years-of-age would be harvested following implementation of this regulation.

Low observed calf:100 cow ratios in the Gravelly-Snowcrest Mountains during the winters of 1979-1980 and 1980-1981 (18-35 calves:100 cows versus 55-68:100 during 1970-75), coincided with low antlered bull:100 cow ratios (Chrest and Herbert 1980, 1981). In some areas of Montana where radiocollared elk were available, antlered bull mortality was as high as 90% annually (DeSimone and Vore 1992). Available evidence suggested that low proportions of mature bulls in elk populations might negatively affect calf production and/or survival and population size (Hines and Lemos 1979, Prothero et al. 1979, and Smith 1980). Concern over the observed low calf:100 cow and bull:100 cow ratios resulted in changes in hunting regulations in HD 324 during 1981. Archery season, which occurred during the rut, was eliminated in HD 324, and kill of antlered elk during the general elk season was restricted to branch-antlered bulls. The BAB regulation also was implemented in HDs 323, 326, and 330 during 1983 and in HD 325 and the northern portion of HD 327 during 1987. Elimination of archery hunting was intended to reduce disturbance of elk during the breeding season. The archery season was restored in 1988. In 1981 and 1982, a point 1 inch in length, branching from the main beam was considered a legal branch. During 1983-1989 a legal branch was redefined to be 4 inches in length.

In 1990, MFWP implemented a brow-tined bull (BTB) regulation in areas that previously had a BAB regulation. A brow-tined bull was defined as having a branch of at least 4 inches on the lower half of at least 1 antler. This regulation was an attempt to reduce the degree of illegal mortality of yearling or "spike" bulls experienced under the BAB regulation (Hamlin and Ross 1990b, 1991, DeSimone and Vore 1992). We estimated illegal mortality of yearling bulls to average 25-35% and be as high as 50% during some years under the BAB regulation (Hamlin and Ross 1990b, 1991). Thirty hunting units had BTB regulations in 1990 and 38 in 1992. By 1998, 64 of 105 Montana hunting districts with a general season for elk had a BTB regulation.

By the mid-1990s, landowner tolerance level and forage carrying capacity of winter ranges were again receiving emphasis and reductions in some elk populations were desired. These reductions required increased harvest of antlerless elk.

MFWP initiated this study in January 1984 (Lonner and Schladweiler 1984) to assess the effects of various hunting regulations and harvest strategies on elk population characteristics and dynamics. The study emphasized breeding biology, reproductive success, calf recruitment, bull survival, seasonal distribution, movements, and habitat use. Effect of hunting regulations and strategies on hunter success, attitudes, and other factors also was evaluated. One objective of the study was not addressed because its conditions were never met. That objective was to: Test the hypothesis that when adult bulls (≥ 2 years old) comprised less than 5% of an elk population during the breeding season, the net reproductive success would be less than when the population had greater than 5% adult bulls. Adult bulls (≥ 2 years old) did not comprise less than 5% of the breeding population at any time during the study period. Additionally, with the definition changed to mature bulls (≥ 3 years old), they were never more than 5% of the population (2-3%).

Terry Lonner and Philip Schladweiler designed and conducted the study during 1984-1988 (Lonner and Schladweiler 1984, 1985, 1986, and 1987). Ken Hamlin and Mike Ross conducted the study from December 1988 to its conclusion.

CHAPTER 2

STUDY AREA

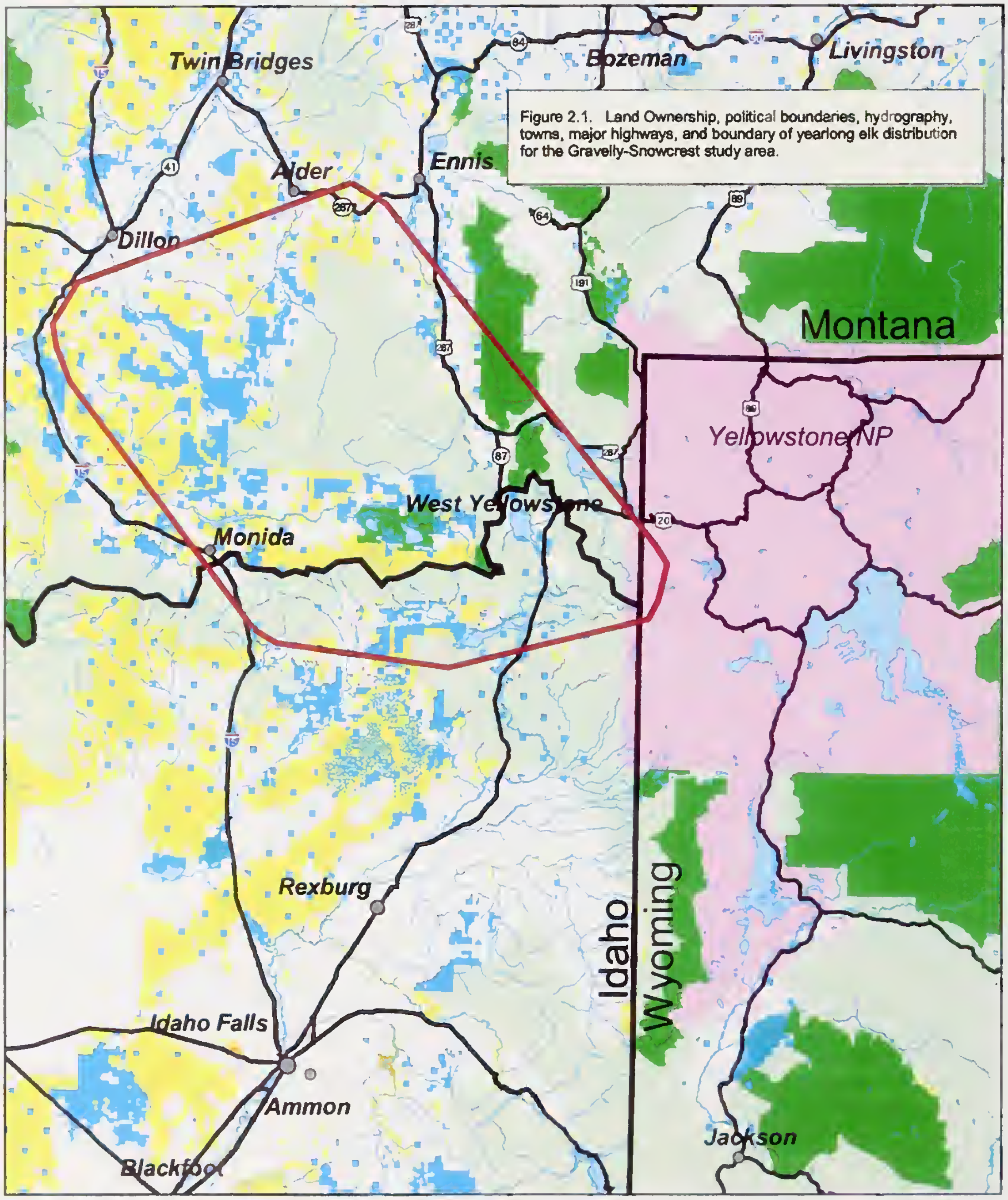
Location, Physiography, Geology, and Soils

The extent of the study area changed over time as we determined normal distribution of elk from radiocollared animals. Generally, the study area comprised the Gravelly and Snowcrest Mountains in southwestern Montana, at the headwaters of the Missouri River (Fig. 2.1). This area lies between approximately 45° 15′ and 44° 15′ north latitude on a north-south axis. On an east-west axis, it is between approximately 112° 45′ and 112° 15′ on the north end and 111° 0′ and 113° 45′ on the south end. Areas included within the study area but outside the Gravelly and Snowcrest Mountains were the Greenhorn Mountain extension of the Gravellys, Blacktail Ridge, Basin-Sage Creeks, the Sweetwater Hills, the Centennial Mountains and associated areas of Idaho, the Henry's Lake Mountains, and the western portion of Yellowstone National Park. Major drainages included the Madison and Beaverhead rivers, near the east and west boundaries, respectively. Other major drainages in the study area were the Ruby and Red Rock rivers. The Montana portion of the study area coincided with the Gravelly Landscape Analysis Area (GLAA) defined by an Interagency planning team (USDA, USFS 1999). Land ownership in the GLAA was: private, 39.2%; USDA United States Forest Service (USFS), 23.8%; USDI Bureau of Land Management (BLM), 21.4%; Montana Department of Natural Resources – State Lands (SL), 12.6%; United States Fish and Wildlife Service (USFWS), 2.0%; and Montana Department of Fish, Wildlife, and Parks (MFWP), 0.9%. The broad area, including portions unused by elk, was about 145 x 110 km (90 x 70 miles) or about 16,000 km^2 (6,300 mi^2). Some marked elk dispersed permanently beyond this area.

Mountain ranges separated by intermountain valleys characterize the physiography of the study area (Fig. 2.2) which is part of the southwestern belt of high elevation mountain ranges in Montana (Pfister et al. 1977). Elevations of the highest mountain peaks are 3,050-3,225m (10,000-10,581 feet) and substantial areas occur above 2,600m (8,500 feet) elevation. Lowest elevations occur on valley bottoms near some elk winter ranges at 1,675m (5,500 feet) along the Madison River, the footslopes of Blacktail Ridge and the Greenhorn Range. Much elk winter range is higher in elevation, some as high as 2,620m (8,600 feet).

Characteristics of this area are the result of several stages of mountain building episodes. The second stage, during the Laramide orogeny, consisting of vertical uplift and block faulting along with some mountain glaciation, provided today's topography. To some extent this mountain building continues today as evidenced by the 1959 Hebgen Lake earthquake (Montagne et al. 1982). Because of this, much of the area is geologically unstable and slumps and unstable stream channels are present.

The uplifted core of these mountain ranges consists of coarse-grained metamorphic rock from the Precambrian period. From the Precambrian period through the late Cretaceous



Elk distribution layer from Kan Hamlin. All other data layers from Natural Resources Information System, Montana State Library, Helena, MT, Idaho and Wyoming Data Clearinghouses. All layers digitized at 1:100,000.

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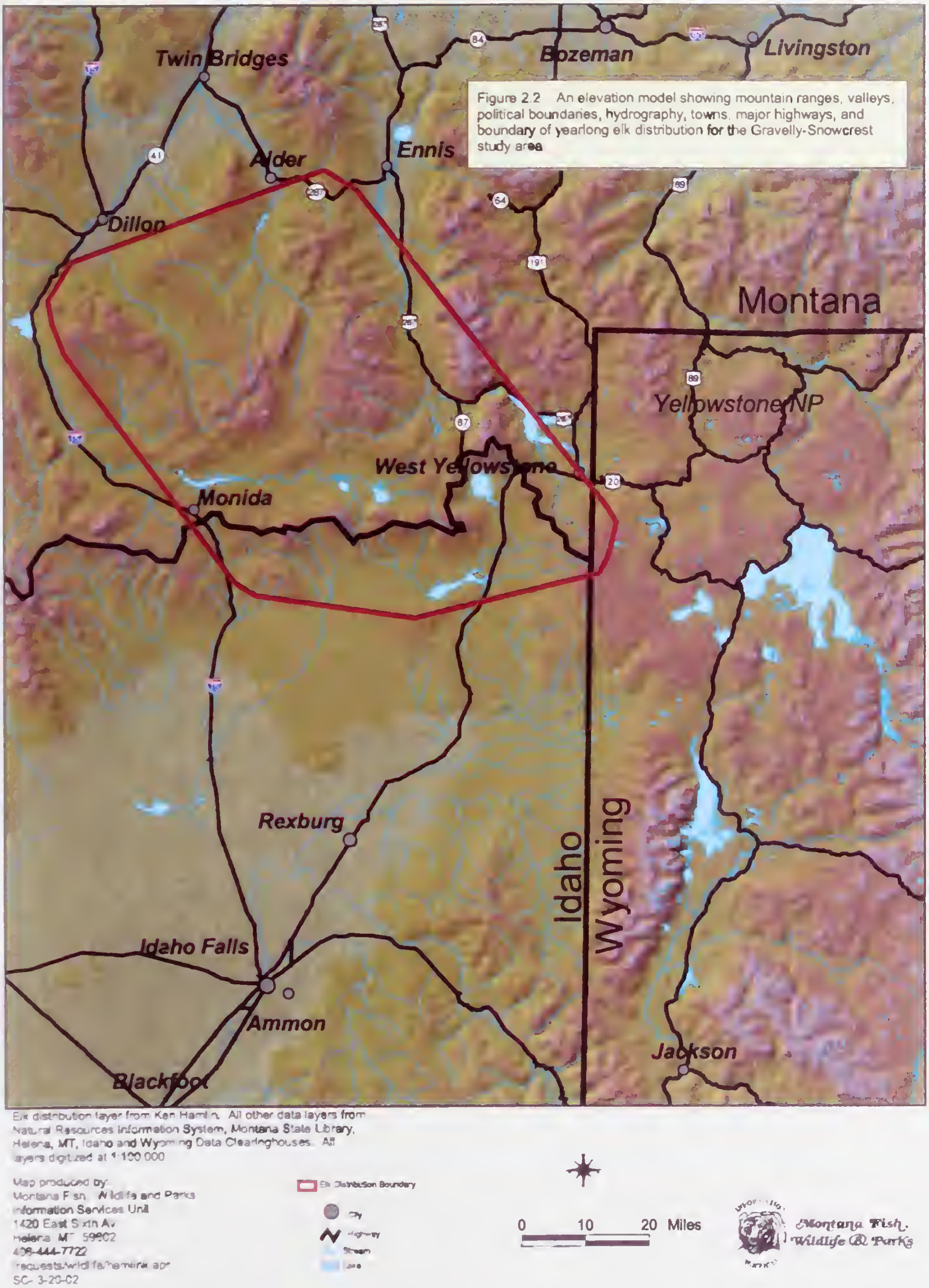
Figure 2.1. Land ownership, political boundaries, hydrography, towns, major highways, and boundary of yearlong elk distribution for the Gravelly-Snowcrest study area.


Twin Bridges
Bozeman
Livingston
Alder
Ennis
Dillon
Montana
Yellowstone NP
West Yellowstone
Monida
Rexburg
Idaho Falls
Ammon
Blackfoot
Idaho
Wyoming
Jackson
Figure 2.2 An elevation model showing mountain ranges, valleys, political boundaries, hydrography, towns, major highways, and boundary of yearlong elk distribution for the Gravelly-Snowcrest study area
Elk Distribution Boundary
City
Highway
Stream
Lake
0 10 20 Miles
Montana Fish, Wildlife & Parks

Elk distribution layer from Ken Hamlin. All other data layers from Natural Resources Information System, Montana State Library, Helena, MT, Idaho and Wyoming Data Clearinghouses. All layers digitized at 1:100 000

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Figure 2.2. An elevation model showing mountain ranges, valleys, political boundaries, hydrography, towns, major highways, and boundary of yearlong elk distribution for the Gravelly-Snowcrest study area.

period invasion and recession of inland seas continued, resulting in deposition of limestones early and shales and sandstones later. Layers of these sedimentary rocks are present along with formations of extrusive igneous rock (Mueggler and Stewart 1980, Montagne et al. 1982). Soils derived from these strata consist primarily of Mollisols in the mountainous terrain and to a lesser extent, Inceptisols and Alfisols. Soils in the valley alluvium are primarily Mollisols-Inceptisols and Ardisols-Mollisols (Montagne et al. 1982).

Climate

The study area is east of the Continental Divide and has a cold-dry continental climate. Mean (30-year) annual temperature at winter range elevation (Alder 17 S) averaged 5.3 °C. December and January have the lowest mean monthly temperature of about –5.6 °C; July and August have the highest, about 16.7 °C. Thirty-year average for annual precipitation at this same station was 34.7 cm. Mean monthly precipitation was lowest in February (0.56 cm) and highest in June (6.3 cm). There were no stations to record temperature and precipitation at summer range elevations, but annual precipitation there is in the relatively dry 50-100 cm range (Montagne et al. 1982). The presence of alpine tundra habitat at high elevations indicates a mean July temperature of less than 10 °C (Pfister et al. 1977). Mean annual precipitation and temperature (Figs. 2.3 and 2.4) indicated that the area was warmer and drier during the study period than previously. Severe winters have been relatively few since 1968. Only in winters 1978-1979 and 1988-1989 were both temperature and precipitation more than 1SD below and above, respectively, the long-term mean. Winter 1978-1979 was the most severe winter during the 1968-1998 period (Figs. 2.5 and 2.6). Generally, winters were warmer and wetter during the study than during the prior 15 years (Figs. 2.5 and 2.6).

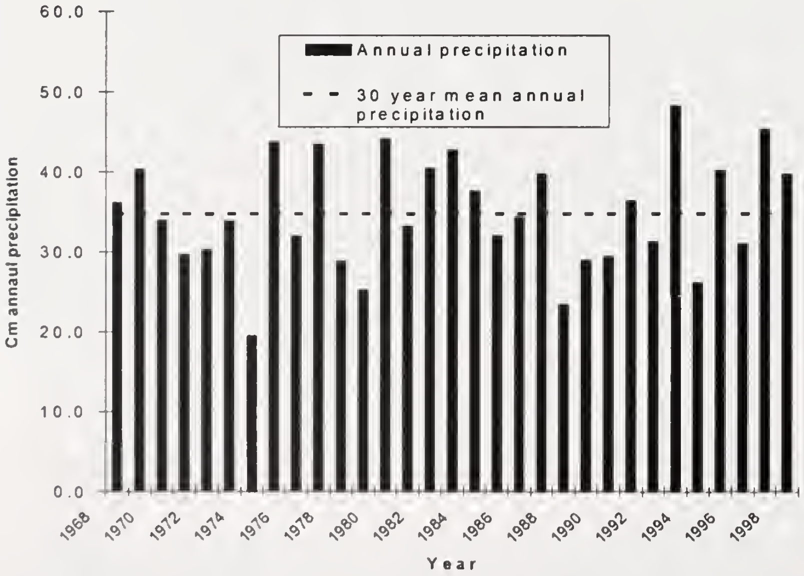


Figure 2.3. Annual precipitation in cm for the Alder 17 S weather station, 1968-1998.

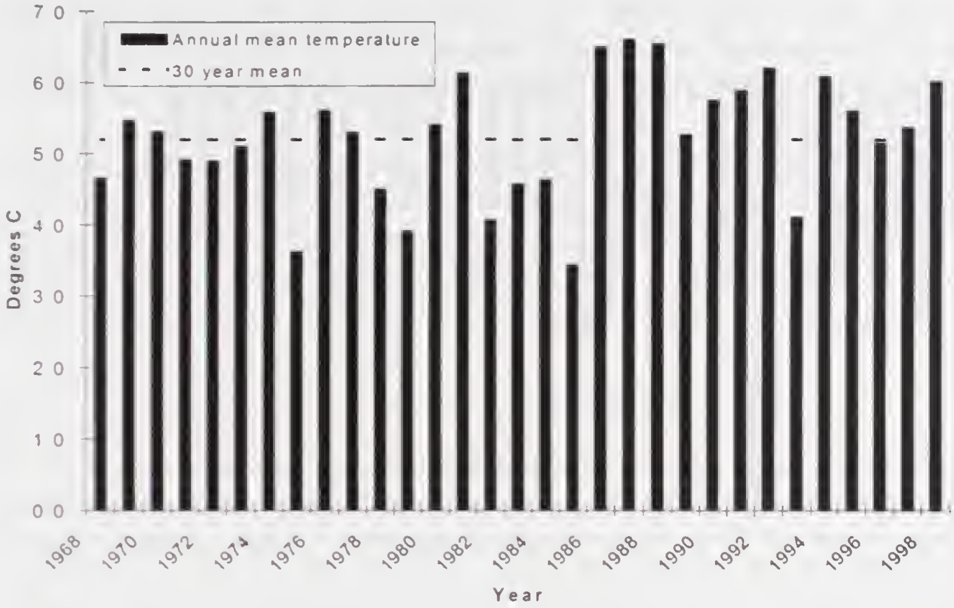


Figure 2.4. Annual temperature for the Alder 17 S weather station, 1968-1998.

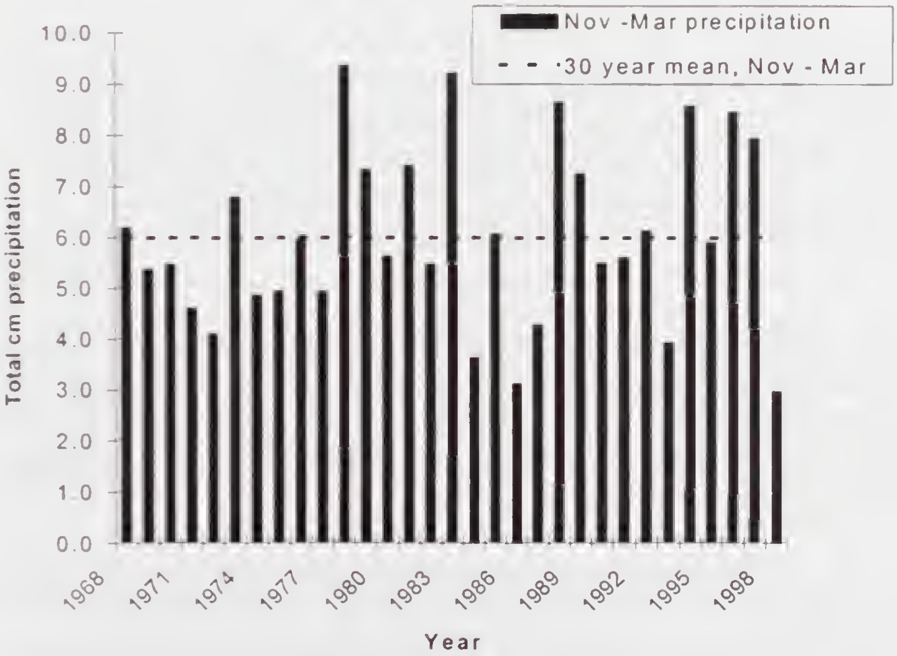


Figure 2.5. Precipitation in cm at Alder 17 S weather station during November-March, 1968-1999. Year equals starting year (e.g. 1968 = 1968-1969).

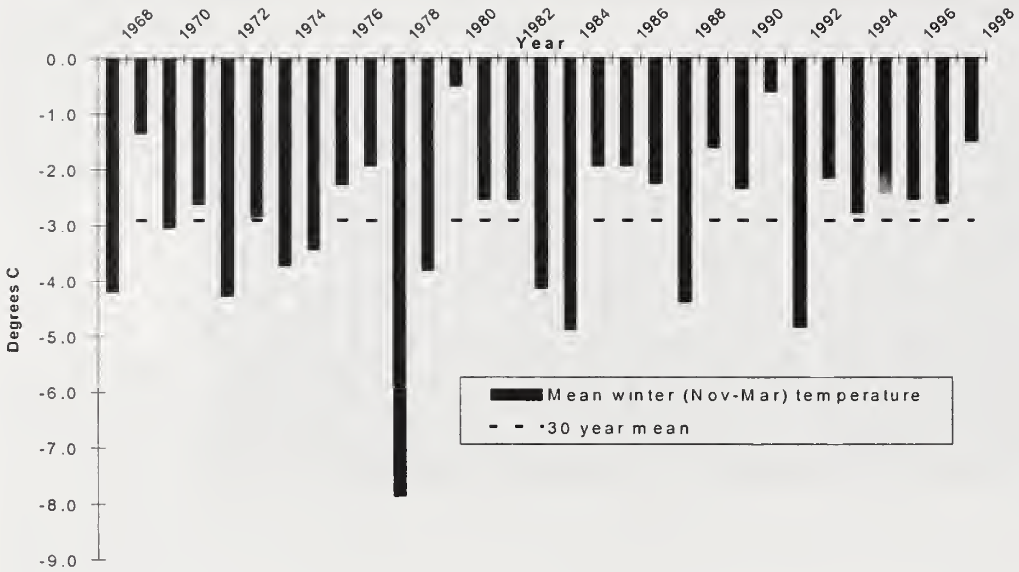


Figure 2.6. Mean winter temperature (November-March) in degrees Celsius at the Alder 17 S weather station, 1968-1999. Year equals starting year (e.g. 1968 = 1968-1969).

Habitat – Vegetation

At least partly because the area is cold and dry, timber cover is relatively sparse in this area. About 20% of the Gravelly Landscape Analysis Area and 47% of the National Forest land is in timber cover. Only a portion of this timber cover provides effective security for elk during the hunting season, however. The USFS estimated that the cover:forage ratio in the Upper Ruby River drainage was 21:79. Of this, road densities reduced the "elk effective cover" to about 15% during summer and 12% during hunting season (USDA, USFS 1992). Other portions of the area such as the east slope of the Gravelly Mountains have more cover, but overall, timber cover is sparse. Although there has been some logging on the area, limited timber cover is natural. Old photographs taken in the area from the 1880s through the 1940s compared with photographs of the same sites taken during the late 1970s (Gilkerson 1980) almost without exception indicate an increase in timber cover from the earlier periods to 1979.

In forested habitat, trees occur by increasing elevation in the following series: limber pine (*Pinus flexilis*), Douglas fir (*Pseudotsuga menziesii*), Englemann spruce (*Picea engelmannii*), and subalpine fir (*Abies lasiocarpa*). Ranging throughout the Douglas fir, spruce and subalpine fir zones is the lodgepole pine (*Pinus contorta*) series. The whitebark pine type intermingles with the subalpine fir series at high elevations. Habitat types present include: *Pseudotsuga/Festuca idahoensis, Pseudotsuga/Symphorocarpos albus, Pseudotsuga/Calamagrostis, Pseudotsuga/Juniperus communis, Pseudotsuga/Arnica cordifolia, Picea/Linnaea borealis, Abies lasiocarpa/Calamagrostis, Abies lasiocarpa/ Linnaea borealis, Abies lasiocarpa/Vaccinium scoparium, Abies lasiocarpa/Arnica cordifolia, Abies lasiocarpa – Pinus albicaulis/Vaccinium scop., Pinus* *albicaulis-Abies lasiocarpa,* and also various *Pinus contorta* community types (Arno 1979). Aspen (*Populus tremuloides*) stands are scattered throughout the upper sagebrush (*Artemisia*)-grassland type and lower-to-mid-elevation timbered types.

Grasslands and sagebrush-grasslands occur below the forest zone and grasslands also occur within and above the forest zone. Sagebrush-grassland is predominantly the *Artemisia tridentata/Festuca idahoensis* type, though the *A.t./Agropyron spicatum* type also is present. Major grassland types at mid-high elevations include *Festuca idahoensis/Agropyron spicatum, F.i./A. canium, and F.i./Deschampsia caespitosa.*

Land Use

Barton Gulch, at the northwest corner of the study area, is one of the sites of earliest documented human use in Montana (9,410 ± 140 yrs B.P., Davis et al. 1989). Other evidence (USFS, unpubl.) indicates that substantial use of the study area was made by Paleo-Indians and this use continued during the middle and late Prehistoric periods. Evidence from the earliest sites indicated human use of deer, but elk remains were not found (Davis 1993). Overall, impact by these peoples on elk probably was light.

The study area was also one of the first places in Montana to have substantial occupation by humans of European descent. Placer gold was discovered in Alder Gulch in 1863 and Virginia City and other small towns were established in June 1863. Within a year or two, more than 10,000 people lived in the immediate vicinity (Burlingame and Toole 1957). This "invasion" resulted in substantial area impacts. Local land disturbance was associated with placer mining and later hardrock mining, and substantial subsistance and market hunting supplied the >10,000 people in the area. Also, there was logging to supply building material and mine timbers, some early livestock grazing that increased substantially later, and an increased incidence of fire associated with increased human habitation.

The most substantial immediate impact on elk may have been market hunting, but the most important long-term impact probably was livestock grazing. Although some livestock grazing on the study area was associated with the early mining, most of the increase in livestock grazing started in the 1880s. Grazing was uncontrolled through 1902 and practically uncontrolled through the mid-1920s (USFS notes, Madison Ranger District, Ennis). Generally, sheep were grazed at the higher elevations during summer and cattle and horses were grazed at lower- to mid- elevations. Areas that are currently winter range for elk were grazed yearlong in some cases. In 1921-1923, an estimated 27,913 cattle and horses and 126,716 sheep grazed the Madison National Forest which included the study area (USFS records). A small portion of this stock was grazed east of the Madison River and in the Tobacco Root Mountains, but most was on the study area. In 1999, about 12,876 cow/calf pairs, 8,150 sheep (6,550 ewe/lamb pairs and 1,600 yearlings), and 210 bison grazed the comparable area of National Forest (Gravelly Landscape Analysis documentation, USFS, 1999). Additionally, about 26,395 cattle, 4,206 sheep, and 577 bison graze Bureau of Land Management land in the area. A reduction in effect beyond numbers also occurred because length of the grazing season also was reduced.

Statewide trends 1867-1998 (Fig. 2.7) best illustrate general trends in livestock numbers for the area. Data for Beaverhead and Madison counties combined, 1940-1998 (Fig. 2.8) illustrate more recent trends. Statewide trends indicated a sharp increase in sheep numbers starting in the mid-1870s, continuing through the early 1900s (Fig. 2.7). A declining trend in sheep numbers then began, continuing through the mid-1920s. Sheep numbers then increased through about the end of WWII (increased demand) and have declined since (Fig. 2.7, Montana Agricultural Statistics Service, www.nass.usda.gov/mt/). Peak numbers were 5,736,000 in 1903 and were 385,000 in 1998. With occasional short declines, cattle numbers increased from settlement to a peak of 3,380,000 in 1974 and were 2,600,000 in 1998. For Beaverhead and Madison Counties, sheep numbers declined from 1941 to 1948 and then were relatively stable through 1960. A long decline began then, reaching a low about 1977. Numbers have been more stable since 1977, but have slowly continued to decline. Cattle numbers approximately tripled between 1940 and 1985 (Fig. 2.8), but have declined by about one-third since 1985. Declines in sheep numbers appear to be mostly related to declines in market conditions (less demand) and the difficulty of finding labor. Predator considerations played a minor role. Similarly, market and social conditions were related to increases in cattle numbers.

Today, livestock grazing remains a major land use and recreation also is very important. Hunting, fishing, sightseeing, and snowmobile touring are the main recreational pursuits. Some logging and mining activity still occurs on portions of the area.

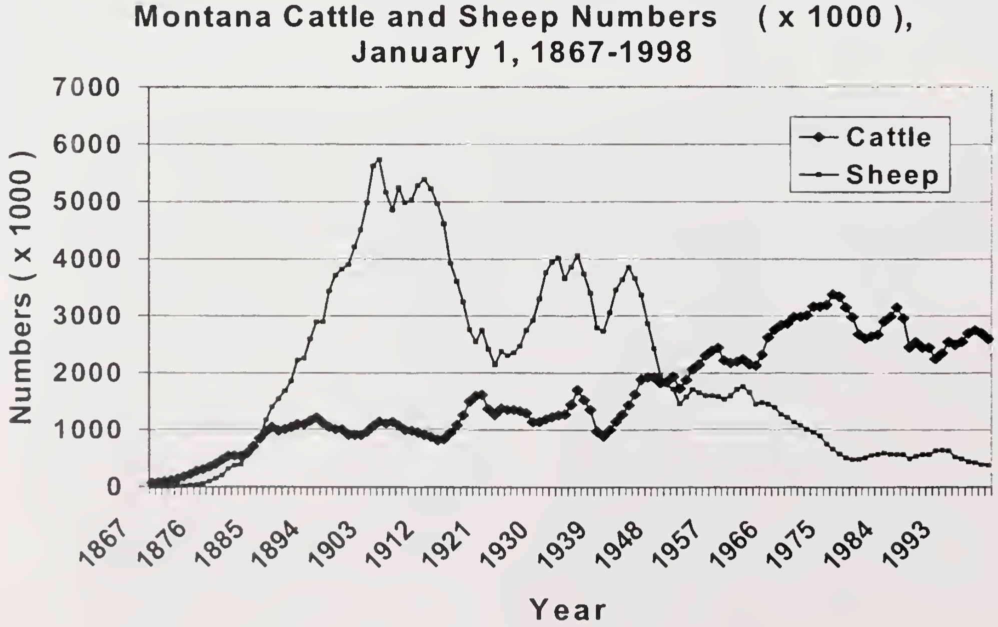


Figure 2.7. Cattle and sheep numbers in Montana (x 1000), 1 January, 1867-1998.

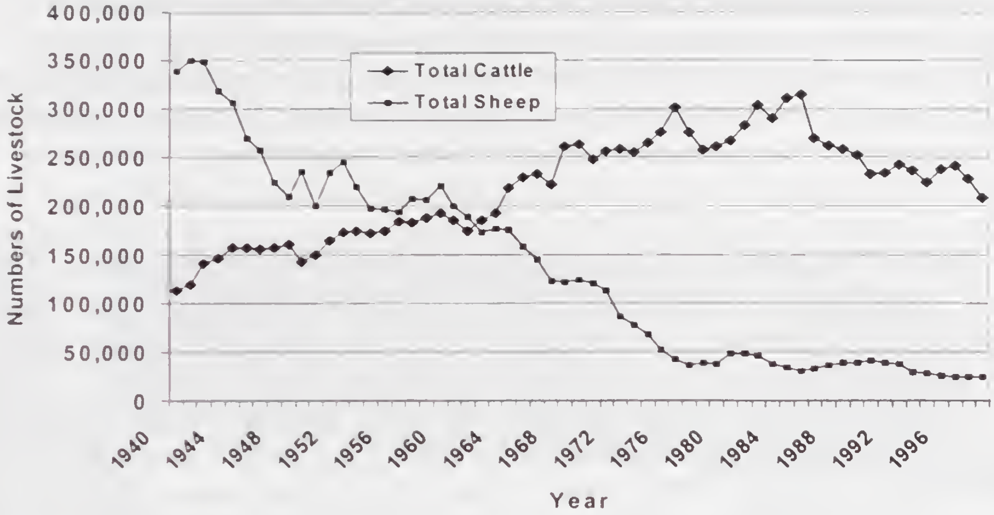


Figure 2.8. Cattle and sheep numbers in Beaverhead and Madison counties, Montana, 1 January, 1940-1998.

Wildlife – Elk History on the Area

Bison were a major influent mammal in the Madison (Lommasson 1948), Blacktail and Centennial (Hodder 1948) Valleys prior to European-American influence; they were gone by the early 1880s. Recently, several ranches in the area have reintroduced small numbers of bison. Other big game species apparently were common as well. Early settlers stated that bighorn sheep (*Ovis canadensis*) were the most abundant game animal in the Blacktail Ridge area (Hodder 1948) but that scabies introduced by domestic sheep resulted in a rapid die-off after 1884. Pronghorn antelope (*Antilocapra americana*) also may have been affected by grazing competition with domestic sheep (Hodder 1948). Mule deer (*Odocoileus hemionus*) are present throughout the area and white-tailed deer (*Odocoileus virginianus*) occur in the valleys and along lower reaches of major streams.

Wolves (*Canis lupus*) were "common" until about 1922 (Hodder 1948). Records of the Ruby Valley Stockgrowers Association (Hodder 1948) show 28 bounty claims for wolves between August 11, 1920 and December 1, 1927. Oldtimers reported that coyotes (*Canis latrans*) …"became excessively plentiful only after elimination of the wolf" (Hodder 1948). We have evidence of some wolf presence in the Gravelly-Snowcrest Mountains by the early 1990s, prior to their release in Yellowstone National Park. In 2000 and 2001, wolves dispersing from YNP established a breeding territory (successful den) in the Gravelly Mountains.

Black bear (*Ursus americanus*) occur in moderate numbers and were documented by this study to be a predator of newborn elk calves. Grizzly bear (*Ursus arctos*) are occasionally observed in the Gravelly and Snowcrest Mountains, but reproduction has not been documented recently. Mountain lions (*Felis concolor*) are present and we documented that they killed some elk calves during winter.

Early records of elk abundance are few, but elk probably were relatively common in the Gravelly-Snowcrest Mountain area. Piles of elk antlers, apparently gathered by Native Americans were present in Sheep Canyon, a drainage of Blacktail Ridge, when European-Americans arrived (Hodder 1948). Granville Stuart (1957) reported that in October 1857 there were "many bands of elk" in the Valley of the Beaverhead (specific reference, Lima area). He and his party spent winter 1857-1858 at the mouth of Blacktail Creek and he stated that "We all lived in elk skin Indian lodges and were very comfortable." He also reported that another party of whites "occupied Indian lodges made of dressed elk skins." In trading with the Indians at this time, Stuart (1957) stated that ..."one elk skin (cost) twenty to twenty-five balls and powder..." . He also reported that there was much less game in the Bighole Valley (during winter) than the Beaverhead Valley and the Snake River plains of Idaho had "no game." Craig and McLucas (1962) reported that the Raynolds expedition of 1859-1860 found elk, deer and antelope abundant in the upper Madison Valley and around Henry's Lake. On 13 April 1863, James Stuart reported observing elk approximately where Virginia City would be established 6 weeks later (Stuart 1876). Henry Edgar's diary reveals that on 27 May 1863, the morning after they discovered gold at Alder Gulch, the prospecting party was frying elk meat for breakfast (Clem 1900). Old photographs provide evidence that elk were processed at butcher shops in Nevada City during the peak of the gold rush in the 1860s (Fig. 2.9). Callaway (1982) stated that in fall 1883 he was part of a hunting party that killed two large elk near Cottonwood Creek in the upper Ruby River drainage. He also reported that, in summer-fall 1886, cowboys in the Centennial Valley killed antelope, deer, and elk for food (Callaway 1982). He said that antelope were extremely numerous and deer and elk ..."were on either side of the Valley in considerable numbers." Thus, just prior to and up to 20 years after the "gold rush period" elk apparently were plentiful within what is now the Gravelly-Snowcrest Mountain study area.

After this time, no reference to elk in the area can be found until the late 1920's, when elk were considered scarce. Records of the USFS (Madison Ranger District, Ennis) indicated that in 1926, deer, elk, bear, and sheep were found in the Lyon Ranger District. They estimated 30-40 elk were in the lower West Fork of the Madison River and 10-12 elk occurred in the east portion of the Centennial Mountains. These numbers, although of questionable accuracy, indicate scarcity. No mention of elk was made for other areas of the Gravelly-Snowcrest Mountains. Eustace (1967) stated that local ranchers reported 6 elk in the Wall Creek area in 1935 and 30 in 1942. USFS reports for 1936 noted that deer, grouse, coyotes, moose, bear and snowshoe hare were observed on the east side of the Gravellys, but did not mention elk.

Hodder (1948) and Rouse (1957) noted that some native elk were present in 1937 when a transplant of elk to the study area was made. At that time, 82 elk from Yellowstone National Park were released at the northern end of Blacktail Ridge, and 26 were released near Lima. West (1941) listed and estimated numbers for elk herds on the National Forests of Montana, and although we have noted that some were present, he did not list any elk for the Gravelly-Snowcrest Mountain area. This indicated that the Gravelly-Snowcrest Mountains were not considered to contain a significant elk population at that time. The Montana Fish and Game Department made its first count of elk in the Wall Creek area in 1947, and in 1948 began regular aerial censuses of important wintering areas in the Gravelly-Snowcrest Mountains. It appears that somewhat more than 1,000 elk were present within the study area in 1948. Specific data collected from that time will be reported with results from the present study. MFWP records indicate that additional transplants of elk in the area were made on the Blacktail in 1951 (46) and Missouri Flats in spring 1953 (19) and winter 1954-55 (29).

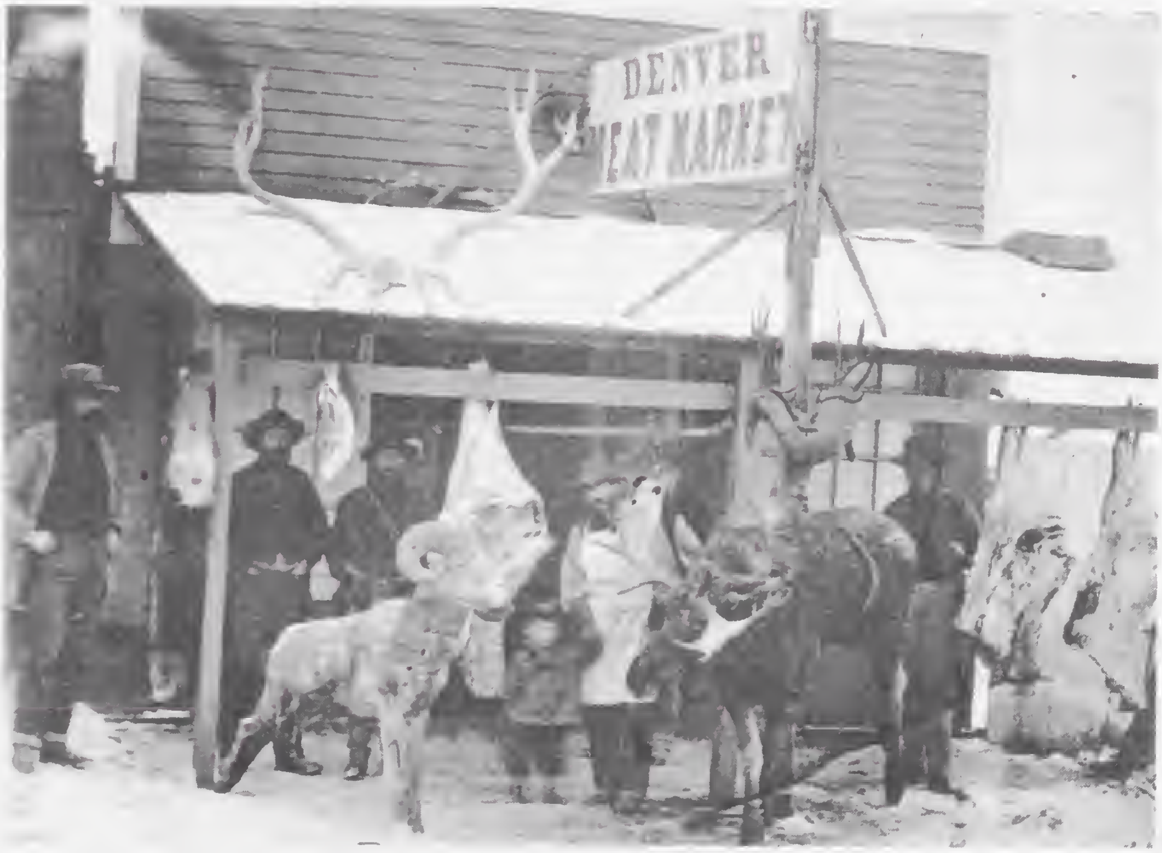


Figure 2.9. Alexander Metzel Meat Market, Nevada City, Montana, 1864 (Courtesy of Montana Historical Society).

MFWP purchased 3 Wildlife Management Areas, primarily for elk winter range, in the Gravelly-Snowcrest Mountain area. In 1960, the Wall Creek Wildlife Management Area (28.6 km^2) on the east slope of the Gravelly Mountains was acquired. The 70.5 km^2 Blacktail Wildlife Management Area on the west slope of the Snowcrest Mountains was purchased in 1972. The 140 km^2 Robb-Ledford Wildlife Management Area, also on the west slope of the Snowcrest Mountains, was purchased in 1988. A total of 240 km^2 of elk winter range in the study area currently is state owned. Hamlin (1993) described contributions of these areas to elk management.

Southwestern Montana (Administrative Region 3) is the major elk producing area in the state. It includes about one fourth of all hunted elk habitat and about half of all elk hunters and harvest (Table 2.1). Within Region 3, the Gravelly-Snowcrest Mountains provide a similar, but slightly higher harvest density and a greater hunter density than the remainder of the Region (Table 2.1). The Gravelly-Snowcrest hunting units (HDs 323, 324, 325, 326, 327, and 330, Figure 2.10) comprise about 3.7% of Montana's hunted elk habitat, but supplied about 7-8% of elk harvest. An average of 8.8 % of the state's elk hunters hunted there during 1992-1996 (Table 2.1). About 18 % of all non-resident elk hunters hunt in the Gravelly-Snowcrest Mountains, proportionally much more than in the rest of Region 3 or the state (Table 2.1). These proportions appear to be steadily increasing. In 2000, 51.2 % of Montana's total elk hunters and 58.5 % of non-resident hunters hunted in Region 3. Of Montana's bull and antlerless elk kill, 58.3 % and 62.8%, respectively, were in Region 3. Similarly, 11.6% of Montana's total elk hunters and 22.6% of non-resident elk hunters hunted in the Gravelly-Snowcrest HDs and harvested 11.5% of bulls and 12.3% of antlerless elk taken in Montana during 2000.

Table 2.1. Distribution of elk habitat, hunters, and harvest in Montana, MFWP administrative Region 3, and the Gravelly-Snowcrest Mountain hunting units (HDs 323. 324, 325, 326, 327, and 330), 1992-1996.

	Elk habitat	Elk hunters	Total elk harvest	Bull harvest	Cow harvest	Calf harvest	Antlerless harvest
R-3 as % of State	26.0	37.4(48.6)[a]	44.6	41.9	46.6	47.8	46.7
Gravelly-Snowcrest as % of R-3	14.4	23.6	17.6	17.3	17.6	19.7	17.8
Gravelly-Snowcrest as % of State	3.7	8.8(17.6)[a]	7.8	7.2	8.2	9.4	8.3

[a] Figure in parenthesis is percent of Montana's non-resident hunters.

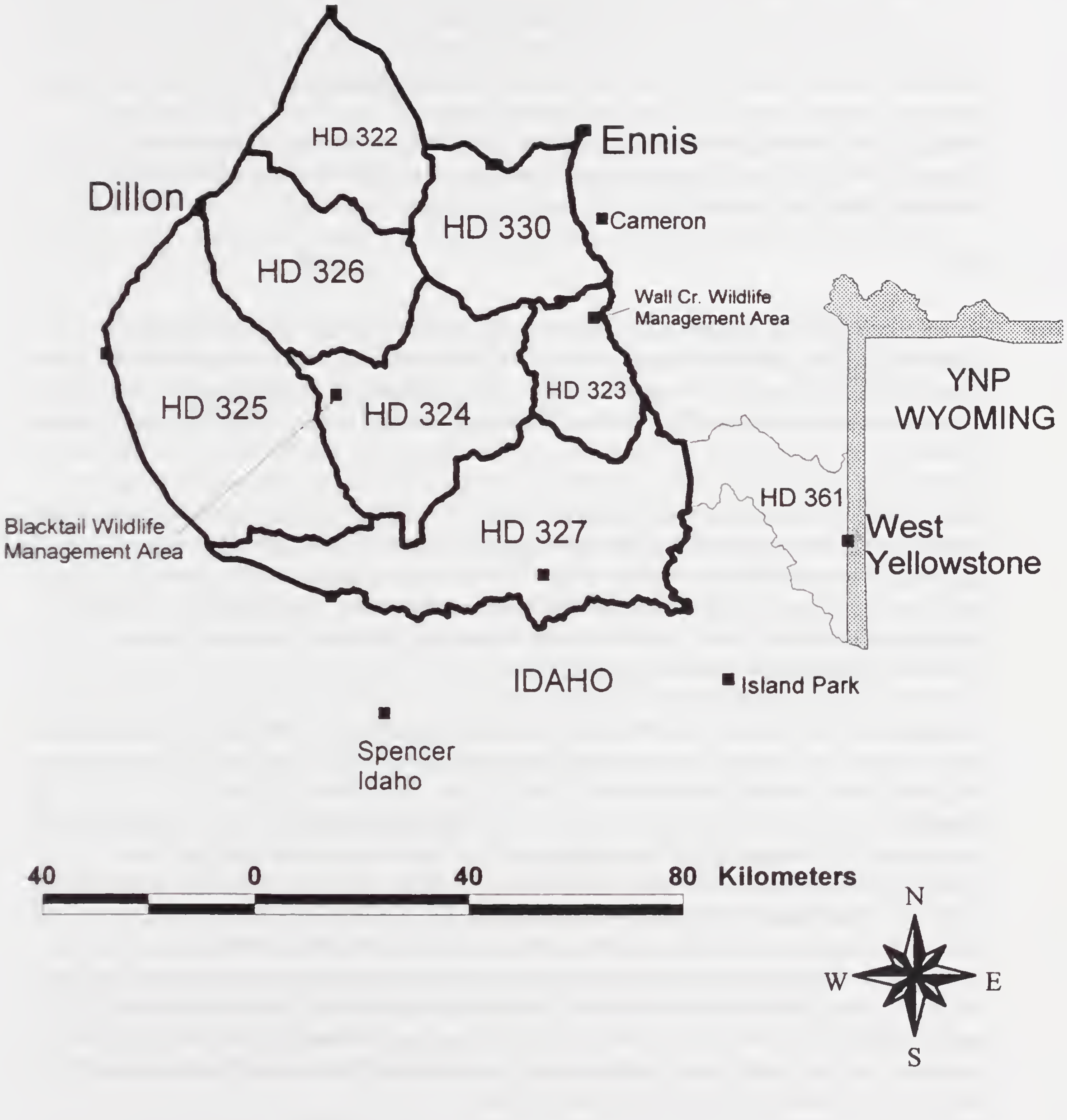


Figure 2.10. Montana hunting districts included in the Gravelly-Snowcrest elk population range. The Most darkly outlined hunting districts also encompass the Gravelly Landscape Analysis Area (GLAA).

CHAPTER 3

METHODS

Methods changed somewhat as personnel and technology changed over a 12-year period. However, because most of our methods were relatively "low-tech", little substantive change in methodology occurred that caused problems of incompatibility among years. Although we primarily discuss methodology below, we also cover or clarify some methods within the appropriate sections of results.

Field

We captured 986 elk during 1984-1995. Twelve were recaptures, for a total of 974 different elk. We released 2 female calves without marking identification and there were 12 mortalities. The total we captured and marked included 71 newborn calves, 509 calves 6-10 months of age, 36 yearling males, 5 adult males, 83 yearling females, and 256 adult females.

We captured 71 newborn calves by hand or with the aid of long handled hoop nets during late May and early June 1984-1988 (Lonner and Schladweiler 1984). Calves were located by searches from a helicopter or horseback. When captured, calves were sexed, weighed, ear-tagged, and marked with an expandable radiocollar with a motion sensitive switch that aided in mortality detection. We released one calf with only eartags. We also obtained blood samples from captured calves.

We captured older calves and adult elk on winter ranges during December to April. Most were captured in February and March. Almost all captures during 1984-1992 were by helicopter drive netting (Beasom et al. 1980); a few bulls were captured with a hand-held net gun fired from a helicopter (Barrett et al. 1982). During March 1989, we captured 43 adult elk by drug immobilization administered by darting from a helicopter. We employed Dick Kenyon, DVM, to administer a mixture of 2.7 mg Carfentanil and 30 mg Xylazine, which generally resulted in recumbent elk within 6-12 minutes. We used Naloxone to reverse the effects of the capture drugs. In December 1992 and after, we used the hand-held net gun and helicopter for all captures. The net gun capture method was used at this time because we wanted to capture male calves and to capture small samples of adult females on scattered small winter ranges. Handling time was kept to a minimum with all techniques. Individual elk were generally processed and released in less than 15 minutes with all capture techniques.

We attached metal eartags to all captured elk except one female calf during both 1994 and 1995. Additionally, we attached radiocollars to 529 elk and individually recognizable plastic/rubber neckbands to 342 elk captured during winter. We released 33 elk with only eartags for identification. We enclosed radio-transmitters in collars made of molded PVC pipe. For females, we used white PVC pipe and a variety of colored symbols on the collar for identification. After 1989, we used black PVC pipe for transmitter collars of male elk. We used individual white symbols on the dorsal surface of the black collars, visible from above, during 1990-1992; no individual symbols were used after 1992 on collars of male elk. We used a variety of colors and symbols for neckbands to facilitate individual identification. After 1989, most transmitters were equipped with motion sensitive switches that aided in detection of mortality. For these transmitters, pulse rate doubled when the transmitter was motionless for 4-6 hours.

The net gunning crew (Helicopter Wildlife Management) was able to effectively select for male calves. Sex ratio of calves captured by drive netting during 1986-1992 was 141 males (43.1%) and 186 females. For capture by net gunning during 1993-1995, the sex ratio was 106 males (76.8%) and 32 females. During the last 2 years, sex ratio was 72 males (86.8%) and 11 females.

Capture-related mortality rate was similar for all capture techniques. We experienced 10 mortalities (1.3%) of elk in 749 captures by drive netting, 2 mortalities (1.2%) in 164 captures by net gunning, and 1 possible mortality (2.3%) in 44 capture attempts by drug immobilization. The possible mortality by drug immobilization was not verified; it was an elk that we hit with a dart, but were not able to find after it escaped into timber before becoming recumbent. It is also possible that mortality associated with net gunning during 1995 may have been higher than recorded above. Five of the captured calves died within 2 weeks of capture, most associated with a proximate cause of predation. Five additional calves died over the next 2 months from malnutrition or predation. It is likely that some of this mortality would have occurred without capture involvement, but it is also possible that the stress of capture predisposed these elk to mortality. If the 5 elk that died within 2 weeks of capture were predisposed by the stress of capture, mortality of net gunned elk may have been as high as 7 (4.3%) of 164 elk. However, this potential extra mortality may not have been specific to capture method. It may have occurred with any capture method during 1995 because of poor condition of elk.

We sexed, aged, and drew blood samples from elk captured during winter. We assigned ages of elk older than calves at capture by examination of dentition using the eruption-wear method (Quimby and Gaab 1957). We usually obtained samples for both whole blood and serum and submitted them for analysis to the Diagnostic Laboratory of the Department of Livestock, State of Montana in Bozeman. In addition to obtaining values for blood parameters, we submitted serum samples for disease testing and pregnancy tests. For calves captured during and after 1990, we also obtained a chest girth measurement with a cloth measuring tape. During 1994, we obtained fecal samples from 49 of the captured elk to assess parasite occurrence and load.

Pregnancy rates were determined by 4 methods during the study, often concurrently. We used the PregMatic 3 ultrasound unit (Animark, Inc., Aurora, Colorado) and blood values for progesterone (Weber et al. 1982) during 1984-1988, blood values for Protein B (Sasser et al. 1986) throughout the study, and rectal palpation during 1989. Additionally, we collected 8 reproductive tracts during the study. We assigned ages for fetuses from these 8 samples with the crown-rump measurement criteria of Morrison et al. (1959). We simultaneously used at least 2, and often 3 methods of pregnancy detection for each elk. Tests of 35 elk for which both blood samples and reproductive tracts were obtained at

Gardiner, Montana (Palmisciano 1986) and the 43 elk for which pregnancy was determined by rectal palpation in 1989 indicated 100% accuracy for the Protein B test of pregnancy (n=78). We determined pregnancy based on the combined evidence of all tests, but placed most confidence in values for Protein B. During 1984-1987 we estimated that the ultrasound unit had an error rate of 6/111 (5.4%). Error was probably because of improper placement of the probe and operator error in interpretation. During the same period, 10 of 144 (6.9%) determinations of pregnancy by serum progesterone level were determined to be in error (all false positives of calves and males). Because we used at least 2 methods of pregnancy determination for most elk and error rates were relatively low for all methods, we believe our pregnancy rate determinations were greater than 95% correct.

We made 13,090 locations of marked elk. Of these, 10,969 were aerial relocations by telemetry from a PA-18 Piper Super Cub. Visual relocations from the ground totaled 519. There were also 976 capture locations and 626 death locations. Visually verified locations totaled 4,459 (34.1%) and 8,631 (65.9%) locations were aerial locations for which the presence of the marked elk was not verified visually. For many or most of these unverified locations, a group of elk was visually verified, but certain presence of the marked elk was not visually verified. Hunters recorded 480 kill sites to the nearest quarter section (160 acres) on USFS Travel Plan maps. Occasionally, USGS topographic maps were used to more precisely locate kill sites. If hunters only identified the kill location to quarter section, we used the Universal Transverse Mercator (UTM) coordinates at the center of the quarter section as the kill location.

We marked all elk locations on USGS topographic maps and recorded date, time, and remarks relating to the observation while in the air or in the field. We then entered location information in the data file as UTM coordinates and elevation in feet from the USGS topographic maps along with animal ID, date, time, and other remarks. We made aerial telemetry relocation flights at approximate 2-week intervals from May through December and approximately monthly during January through April. Prior to 1990, we visited potential mortality sites only when visual cues suggested mortality or location of the elk was the same for 2 successive locations. After 1989, when the motion sensitive switch in the transmitter indicated a potential mortality, we hiked to the site of the location to investigate status of the elk and determine cause of death.

We conducted aerial counts of elk on winter ranges from PA-18 Super Cub aircraft during late January to early March each year, depending on weather conditions. We recorded total numbers by group and location and number of bulls by category of yearling, 2 years old, and ≥3 years old. We did not attempt to identify elk as calves or adults from the air during winter/spring. Because of greater visibility of the entire population over a wider area, we usually used the aerial classification of bulls as representative of the population ratio. We attempted to count the entire Gravelly-Snowcrest elk population in one day by using 2 aircraft but occasionally 2 days were required. We did not believe substantial movement between winter ranges occurred within this short interval. Usually, only one aerial count of each winter range was made each year. However, when conditions indicated that more than usual numbers of elk may have been missed on some winter ranges, some were re-flown. On the Wall Creek Wildlife Management Area (WCWMA), MFWP Area Manager Fred King made ground counts of elk several times per week in the vicinity of the WMA, recording number by group and location. For years prior to 1984, we used census data in MFWP files and summary reports (e.g., Peek and Chrest 1966).

During mid to late winter we conducted classifications from the ground of elk wintering on the WCWMA and Blacktail Wildlife Management Area (BTWMA). Classifications on some other winter ranges also were made during some years. Usually, we attempted to record the highest total number of elk in unduplicated classifications. However, it is possible that some duplication occurred without our knowledge when classifications occurred over 2-day periods. We used Celestron C90 and Bausch & Lomb 15-60X spotting scopes to observe elk during these classifications. One person viewed elk through the scope and called off the classification while another person recorded the calls on a mechanical counter as: cow, calf, yearling bull, 2-year-old bull, or older bull. When possible, we recorded yearling bulls as spike or branch-antlered. During mid- to late-July, 1984-1990 and 1995 and 1996, we classified elk on summer range to obtain calf:100 cow ratios as early as possible. Summer classifications were from the ground during 1984, from the ground and air (Piper Super Cub) during 1985, and from a helicopter during 1986-1990 and 1995 and 1996.

We operated hunter check stations each year 1984-1996 to obtain samples of sex and age of kill, diastema, antler points and length, and characteristics and opinions of hunters. During 1984 and 1985, we operated check stations on the Ruby River road and at various locations on the east side of the Gravelly Mountains. From 1986-1996, the check stations were on the Ruby River road just above Jack Creek, at Lions Park on the east edge of Ennis, and on the Blacktail road at the Matador ranch headquarters. Check stations were operated during the opening Sunday and Monday and during weekend days thereafter until the season ended. We opened the stations about 1000 hours and closed them for safety reasons when returning vehicles began using their headlights.

Through 1988, mandibles of elk were examined at check stations and age assigned by the eruption-wear technique (Quimby and Gaab 1957). During 1989 and after we also collected the first incisor (I_1) of elk estimated to be 3 years old or older. We assigned collection numbers to these incisors, cleaned them, cut off about 1 cm of root tip, and sent these root tips to Matson's Laboratory (Milltown, Montana) for aging by examination of cementum annuli (Hamlin et al. 2000). We also attempted to collect the entire mandible of all marked elk, which provided us with samples of known-age mandibles. To obtain samples of all ages, we also collected mandibles from elk of a variety of ages. To increase the sample of ages for antlerless elk, we sent jaw tags to hunters who received an antlerless permit. We placed 55 gallon barrels outside the check stations and USFS offices in the area in which hunters could place the heads or mandibles of antlerless elk with identifying tag during times the check stations were not open.

We measured length of the diastema to the nearest millimeter from the posterior part of the canine (last incisor) to the anterior part of the first premolar (Reimers 1972). This measurement was intended as an index of growth and age. When possible, we recorded field dressed weight for calf elk killed by hunters. For male elk, we recorded number of points ≥ 1 inch in length on each antler and length of each main beam in millimeters. We considered the most posterior projecting antler point near the antler terminus to be the end of the main beam.

We also asked questions and recorded answers about number of hunters, days hunted, area hunted, hunter origin, and area of kill. In 1984, 1989, and 1994 we randomly asked hunters at check stations if they would respond to a special questionnaire. We recorded their name and address if they responded positively. After the hunting season we sent questionnaires covering a variety of aspects of hunting in the Gravelly-Snowcrest Mountains to these hunters. We also used results from the Statewide Harvest Questionnaire (SWHQ) for information on hunter numbers, kill, hunter effort (days), sex and age class of kill, distribution of kill by HD and time period, and antler point data on male kill. Some harvest-related data were not available from the SWHQ during 1996-1998.

During winters 1989, 1994, and 1995 we collected samples of elk urine in snow to assess the efficacy of various urinary metabolite ratios as indicators of body condition and forage intake for elk (DelGuidice et al. 1989, DelGuidice et al. 1991a, Garrott et al. 1996, Pils et al. 1999).

Analysis

Statistical proceedures generally followed Zar (1984) and we used STATISTICA software (StatSoft 1997) for analysis and tests.

Population Numbers Estimation

Mortality Rate Method

The foundation for this estimate of elk population numbers was the hunting mortality rate of radiocollared adult cow elk, the number of cow elk estimated killed by hunters, and post-season sex/age classifications. We adjusted harvest estimates for Gravelly-Snowcrest HDs from the SWHQ by sex and age (bulls, cows, calves) based on proportions observed at check stations. As an example, below we calculate the population estimate for 1988-1989.

- 837 (adjusted cow harvest) ÷ 0.1429 (hunting mortality rate of radiocollared adult cows) = 5,857 (adult cows pre-season)
- 837 × 0.218 (wounding loss rate) = 182
- 5,857 – 837 (adult cow harvest) – 182 (estimated adult cow wounding loss) = 4,838 adult cows post-season
- 4,838 adult cows × 0.451 (calves:cow post-season classification) = 2,182 calves
- 4,838 adult cows + 2,182 calves = 7,020 antlerless elk post-season
- Total bulls = 6.1% of post-season classification

- Y (Total population) = 7,020 + 0.061Y
- 0.939Y = 7,020
- Y = 7,476 Total elk post-season
- Total bulls = 7,476 – 7,020 = 456 , 36 BTB, 420 yearling bulls (from classification)
- Post-season population estimate = 7,476 Total, 4,838 cows, 2,182 calves, 36 BTB, 420 yearling bulls.

As with any method of population estimation, the final product is only as good as the quality of the input data. Thus, the extent to which the hunting mortality rate of radiocollared cows, wounding loss data, the SWHQ and check station data, and post-season classifications represent the entire population each year reflected on the accuracy of the estimate. One or all of these parameters may vary in their accuracy each year, but we used this method only between 1987-1988 and 1995-1996 because we believed that radiocollared cows were either not well distributed or too few in number in other years. We ignored natural losses in these estimates because our data indicated it was minor during the October-March period covered by these estimates.

Age Structure Reconstruction – Method 1

To accomplish age structure reconstruction we determined ages for hunter-killed female elk at check stations and mandibles left in the barrels during 1984 through 1996. We then calculated numbers of each age/year cohort harvested by multiplying the percentages in each age by the total harvest estimated by the SWHQ. This number was multiplied by the correction figures for wounding loss and natural loss to estimate additional elk from a cohort that died during the year. These numbers for each cohort were added together as the cohort aged to estimate original cohort size at 5 months of age (beginning of first hunting season). We assumed a maximum age of 20 years for females based on our aging data. For this method, data were produced that allowed estimation of population size from spring 1988 through spring 1991.

Because elk are long-lived, we could not estimate numbers for all age classes through 20 years of age with direct aging. For age classes older than those for which we had estimates we added a percent of total population older than that age to our estimate. For example, based on data from 1984-1989, we determined that 12.0% of adult females were ≥ 9 years old. We used this information to increase our estimate based on numbers in ages 1 through 8 years. To estimate total cohort size we used these long-term averages to estimate numbers in ages 13-20 for 1984 through 7-20 for 1991. We did not make estimates using this method after 1991 because too great a proportion of the cohort would have been based on estimated living elk rather than documented harvest.

Once the estimate of total number of cows was made for each year, we used calf:cow ratio and percent bulls from classifications to expand estimates to total elk. As an example, below we calculate the population estimate for 1988-1989, the same year for which we provided an example with the mortality rate method.

For the cohort of females that was 1 year old (1 year, 5 months) during fall 1989, we estimated that 738 were harvested during 1989-1996 based on proportions of ages recorded at check stations expanded to total numbers estimated from the SWHQ. Additionally, we estimated that 190 were wounding losses and 60 were natural losses during the period. Finally, we estimated that 133 remained alive after the 1996 hunting season. The sum of these estimates was a total cohort size of 1,121 1-year-old female elk during spring 1989. We used the same method to estimate 804, 606, 486, 418, and 264 females for the 2-, 3-, 4-, 5-, and 6-year-old cohorts, respectively for spring 1989. The total of these numbers was 3,699 females age 1-6 years old during spring 1989.

- 3,699 female elk ages 1-6, spring 1989.
- For 1984-1989, 79.13% of cow harvest was < 7 years old. Thus, 3,699 = 0.7913Y, Y = 4,675 total females 1-20 years of age, spring 1989.
- 4,675 cows × 0.45 calves:cow (spring classification) = 2,104 calves.
- 4,675 cows + 2,104 calves = 6,779 antlerless elk.
- Bulls = 0.061 (0.056 yearling, 0.005 BTB) and antlerless = 0.939 of population (spring classification).
- 6,779 antlerless ÷ 0.939 (antlerless as a proportion of population) = 7,219 Total elk
- Total elk = 4,675 cows, 2,104 calves, 404 yearling bulls, 36 BTB = 7,219.

Age Structure Reconstruction – Method 2

For method 2 of estimating population size by use of age structure reconstruction we used the same data produced by calculations for method 1, but in a different way. Here, we used the estimated 1989 yearling female cohort size and spring classifications rather than summing up age cohorts as in method 1. We were able to use this method for 1983-1984 and 1985-1986 through 1990-1991. We did not use this method for 1984-1985 because we did not believe the calf:cow ratio recorded that year was valid. The recorded ratio was not validated by subsequent age structure data. We did not make estimates after 1991 because as with method 1, estimates of cohort size would have contained too high a proportion of estimated living elk after that year. Below, we present the example for 1988-1989 to make the same year comparison with the other methods.

- 1,121 10-month-old female calves, spring 1989 (see method 1 above) × 2 (equal numbers of male calves) = 2,242 total 10-month-old calves, spring 1989.
- Spring 1989 classification = 45 calves/100 cows.
- 45 ÷ 145 = 0.3103 = calves as a proportion of antlerless elk.
- 2,242 calves ÷ 0.3103 (proportion of antlerless population) = 7,225 antlerless elk.
- Bulls = 0.061 (0.056 yearling, 0.005 BTB) and antlerless = 0.939 of population (spring classification).
- 7,225 ÷ 0.939 (antlerless as proportion of population) = 7,695 Total elk.
- Total elk = 4,983 cows, 2,242 calves, 432 yearling bulls, 38 BTB = 7,695 Total elk.

Mortality/Survival

In addition to providing location information, radiocollared elk provided information on mortality rates and causes of mortality for elk. Information for newborn calves was used starting with capture and continued until death or transmitter failure. For elk captured at 7-9 months, we recorded monthly mortality information starting 1 January or the first day of the month following capture through 1 June. For elk captured at 1 year and older, we did not use mortality information until they started the next biological year on 1 June. There was little mortality in the intervening period. For some purposes, primarily geographical distribution of deaths, we used mortality information from neckbanded, eartagged, and censored (failed transmitter) transmitter-collared elk. We describe use of these elk for analysis in the appropriate Chapters.

We report mortality/survival information of transmitter-collared elk only as a binomial estimator (deaths or survivors /total sample). Elk had to be accounted for (survive or die) throughout the biological year to be included in the sample. Transmitters that failed during the year were excluded (censored) from the sample unless we made calculations for sample periods shorter than a full year, such as hunting season. We did not calculate daily survival rates. For some analysis we calculated survival (S) using the binomial estimator with a variance, $VAR(S) = S(1-S)/n$ (White and Garrott 1990).

The availability of large annual samples of ages from harvested elk enabled us to compute mortality rates by life table analysis (Caughley 1977, Krebs 1978, DeYoung, 1989, and Zager and Leptich 1991). For this type of analysis it is important that the age distribution be stable and that the rate of population increase be zero or known. These assumptions should at least be approximated (Caughley 1977). Our data indicated that for most of the time period involved, we could meet the assumption of a stable age distribution. Also, within the period of analysis, we could estimate the rate of population increase (r) from aerial trend surveys. We chose to bracket the rate of increase between values of $r = 0.032$-0.065 (see Population Numbers Chapter). Also, we could use the cohort analysis and telemetry data to adjust the age structure of hunter-killed elk to correct for hunter selection, thereby approximating standing age structure. We used the slope of the regression of natural log of numbers in age class against age to calculate survival ($S = e^{\beta}$, where e = inverse of natural log and β = slope of the regression line).

We also calculated survival by the same method, but rather than use all ages over the course of the study as one sample, we calculated the regression for each cohorts' (1983-1993) life table. This allowed us to ignore hunter selection because this was accounted for in age structure over the life of the cohort. Also, we did not have to correct for population growth in these calculations because we calculated survival separately for each cohort.

We used the same age structure/life table data to calculate survival (S) and mortality (M) by age class for each cohort. For this calculation, $M(r) = \ln N_1 - \ln N_2$. Mortality rate (r, instantaneous) equaled natural log of number of elk in age class 1 minus natural log of numbers in age class 2.

Movements, Home range, and Habitat use

This study was not designed as a habitat use, home range, or movements study. Information gathered during the study allowed us to examine some aspects of these subjects at a macro level, however.

We used the Animal Movements extension (Hooge et al 1999) of ArcView 3.2 (Environmental Systems Research Institute 1999) to analyse and display movements and home range information for elk. We used the minimum convex polygon (Mohr 1947) to estimate home range size.

For habitat use analysis, we used habitat layers (vegetation, roads, timber stands, land ownership) identified, mapped and digitized by the Gravelly Landscape Analysis team. These files were kindly provided by Jina Mariani and Jim McNamara of the USFS, Beaverhead National Forest. We converted these files to ArcView files and intercepted them with the elk telemetry data files for analysis.

CHAPTER 4

PHYSICAL CHARACTERISTICS AND CONDITION PARAMETERS

Weights

Field dressed weights of hunter-killed calf elk (Table 4.1) were different among years (ANOVA, F=2.57, P=0.005). Average annual weights varied from 83.9 kg (185.0 lbs) in 1985 to 67.0 kg (147.7 lbs) in 1989. Individual calf weights ranged from 27.2 to108.9 kg (60-240 lbs). The range was 43.1-104.3 kg (95-230 lbs) when the lightest and heaviest calves were dropped from the sample. Post Hoc LSD tests of means indicated few significant differences among years at alpha = 0.05. Mean weight for 1985 (the highest mean) was different from 1987, 1988, 1989, 1991, 1992, 1994, and 1996. Mean weight for 1989 (the lowest mean) was different from 1985, 1986, 1990, 1993, 1994, and 1995. There were no significant differences among years for the more conservative Sheffe tests, however. Weights for autumn 1994, the only year in which we observed significant over-winter mortality of calves, differed only from 1985 and 1993 (LSD tests, $P < 0.05$). Weights of calves born during the dry summer of 1988 were lower than average, but only significantly different than weights during 1985 and 1993. Weights of calves during autumn 1989 were the lowest of all years. This may have resulted from poor condition of females during the breeding season of 1988 and after the hard winter of 1988-1989.

Table 4.1. Field dressed weight (kg) of elk calves, Gravelly-Snowcrest Mountains, October and November, 1984-1996.

Year	Male	Female	Total[a]	Weighted Total[b]
1984	82.3(7)[c]	74.6(10)	77.7(17)	78.4
1985	80.7(4)	87.0(7)	84.7(11)	83.9
1986	81.2(8)	71.9(11)	75.8(19)	76.6
1987	78.2(2)	66.6(6)	69.5(8)	72.4
1988	75.2(9)	67.4(10)	71.1(19)	71.3
1989	66.6(10)	67.4(12)	67.0(22)	67.0
1990	83.4(4)	74.8(10)	77.2(14)	79.1
1991	74.2(10)	69.7(14)	71.4(26)	71.9
1992	74.4(11)	67.6(8)	71.5(19)	71.0
1993	87.6(6)	73.7(10)	78.9(16)	80.6
1994	71.7(9)	69.3(11)	70.4(20)	70.5
1995	76.8(4)	76.9(4)	76.8(8)	76.8
1996	78.0(11)	68.6(12)	73.1(23)	73.3
Mean[d]	77.7(13)	71.9(13)	74.3(13)	74.8

[a] Total includes unknown sex calves.

[b] Mean of males and females weighted equally.

[c] Mean (sample size).

[d] Mean of annual means (years).

The average aerial count for elk increased from 4,207 during 1984-1985 through 1988-1989 to 7,310 (1.74x) during 1991-1992 through 1995-1996. Averages of the weighted totals for calf weights between the two periods (74.24 kg and 74.44 kg, respectively) did not differ ($t = -0.058$, $df = 8$, $P = 0.955$).

Weight has generally been considered an indicator of nutritional status in deer (McEwen et al. 1957, Klein 1970, and Hamlin and Mackie 1989). Although little data are available for elk, the same relationships should apply. The lack of significant differences in calf weights among years may have occurred for a variety of reasons. Although the elk population approximately doubled during the period, forage conditions may not have been much different among most years. Sample sizes were relatively small, variability was high, and only large changes in weight were significant at these sample sizes. The scales used for weighing were of relatively poor quality, and weights were likely affected by equipment and operator problems. However, some significant differences did occur, and these seemed to indicate the importance of drought and severe winters to subsequent calf weight.

We obtained heart-girth measurements (Table 4.2) from calves captured during winter-spring 1990-1995. Calves captured by netgun in 1993-1995 were intentionally male-selected and thus also may have been selected for large body size. Thus, their weights probably were not comparable with those of earlier drive net captured calves. For years 1990-1992 (Table 4.2), largest heart-girths were observed in 1991. Both weight (Table 4.1) and heart-girth (Table 4.2) measurements indicated that the 1990-1991 cohort was larger than the 1989-1990 or 1991-1992 cohorts. Also, calves of both sexes were consistently larger on the Blacktail Wildlife Management Area than on the Wall Creek Wildlife Management Area.

Weights of elk older than calves were not obtained at Gravelly-Snowcrest check stations because of limitations of equipment. However, some field dressed weights of adult elk from Gravelly-Snowcrest hunting districts were obtained at the Gallatin check station. Three yearling females averaged 149.6 kg and ranged from 123.4-175.1 kg. Fifteen females ≥3 years old averaged 159.2 kg and ranged from 134.3-182.8 kg. Five yearling males averaged 144.1 kg and ranged from 132.5-161.5 kg. Eight 2-year-old males averaged 164.0 kg and ranged from 134.3-188.7 kg. Five males ≥3 years old averaged 209.3 kg and ranged from 157.9-238.6 kg. These weights were similar to or greater than those reported for the Flying D Ranch in HD 311 (Arnaud 1996) and the Northern Yellowstone population (Quimby and Johnson 1951).

Diastema

Diastema length is considered an index of skeletal growth. Greater diastema length by age class was also believed to represent better nutritional conditions/growth rate (Reimers 1972). The 95% confidence intervals of mean diastema lengths for all years overlapped and ANOVA ($F_{12,669} = 1.20$, $P = 0.28$) indicated no significant difference among years in

Table 4.2. Heart-girth measurements in cm for elk calves captured with drive nets during February on the Wall Creek Wildlife Management Area (WCWMA) and Blacktail Wildlife Management Area (BTWMA).

Sex — Location	Statistic	1989-1990[a]	1990-1991	1991-1992
Males—WCWMA	Mean	125.7	128.3	125.5
	n	17	22	17
	S_x	5.3	5.3	4.3
	Range	118.1-137.2	119.4-137.2	116.8-132.1
Males—BTWMA	Mean	126.5	131.1	128.3
	n	23	14	17
	S_x	5.8	5.6	5.8
	Range	113.0-137.2	121.9-138.4	116.8-138.4
Females—WCWMA	Mean	124.0	126.7	123.2
	n	21	30	17
	S_x	6.9	5.1	5.1
	Range	101.6-134.6	114.3-139.7	113.0-132.1
Females—BTWMA	Mean	126.2	128.5	126.0
	n	23	30	24
	S_x	4.8	5.6	5.1
	Range	116.8-134.6	116.8-135.9	116.8-133.4

[a] Birth year-capture year.

diastema length of hunter-killed elk calves (Table 4.3). We expected weight and diastema length to be positively correlated as indicators of growth. However, there was no significant correlation ($R^2 = 0.038$, $F = 0.439$, $P = 0.52$) between weight and diastema length. Precipitation was below average in 1988 and 1994 (Fig. 2.3) and diastema lengths were below average in both those years. However diastema lengths were similar or lower in 1984, 1985, 1986, and 1989. Even with larger sample sizes for diastema than weight, diastema did not appear to be a sensitive indicator of condition for this elk population. However, similar to weight data, diastema length tended to be smaller in years of drought and the year following drought or severe winters.

Population numbers were approximately twice as high at the end of the period as at the beginning but there was no relationship between diastema length (Table 4.3) of calves and population density. Mean weighted diastema length was 81.7 mm during 1985-1989 and 82.2 mm during 1992-1996 ($t = -1.19$, $df = 8$, $P = 0.268$).

Some have hypothesized that early stunted or slow growth might be carried throughout life in the form of size or other physical measurements. Because of the long-term nature of this study, we had the rare opportunity to examine this hypothesis by measuring annual diastema length of cohorts. Most annual samples were >20 for each cohort-year at ages ≤5.5 years (Table 4.4). Sample size was as low as 7 for some years at ages >5.5 years, although most *n* were >10.

Table 4.3. Diastema length in millimeters for hunter harvested elk calves, Gravelly-Snowcrest Mountains, October-November, 1984-1996.

Year	Male	Female	Total[a]	Weighted Total[b]
1984	81.4(7)[c]	79.9(13)	80.5(20)	80.7
1985	81.8(20)	81.7(34)	81.7(54)	81.8
1986	82.2(16)	80.7(36)	81.6(56)	81.5
1987	82.1(21)	83.9(33)	83.5(58)	83.0
1988	79.3(15)	82.0(42)	81.3(57)	80.7
1989	82.0(38)	81.4(43)	81.7(84)	81.7
1990	84.3(13)	84.0(29)	84.1(42)	84.2
1991	83.3(31)	82.4(45)	82.7(81)	82.9
1992	82.3(32)	81.7(43)	82.0(76)	82.0
1993	84.0(23)	81.7(38)	82.6(63)	82.9
1994	81.3(41)	82.0(67)	81.9(111)	81.7
1995	82.3(20)	82.3(23)	82.3(45)	82.3
1996	82.3(30)	82.2(56)	82.2(86)	82.3
Mean[d]	82.2(13)	82.0(13)	82.2(13)	82.1(13)

[a] Total includes unknown sex calves.

[b] Mean of males and females weighted equally.

[c] Mean (sample size).

[d] Mean of annual means (years).

We did not observe a consistent pattern of cohorts retaining their relative diastema size position as they aged. For example, mean diastema lengths of the 1984 cohort were shortest or second shortest at ages calf through 2 .5 years, but were longest or second longest at 5.5, 7.5, and 10.5 years (Table 4.4). Similarly, the 2 calf cohorts with the longest mean diastema length (1987 and 1990) were the cohorts with the shortest or below average diastema length in some other years (Table 4.4). It did appear that cohorts prior to 1985 generally had shorter mean diastema length at all ages than cohorts after 1985, though data were limited (Table 4.4). We did not show cohorts prior to 1981 and older than 10.5 years because sample sizes were only 3-6. Those limited data indicated that the diastema of the 1979 cohort was consistently shorter than that of other cohorts, 1976-1984. This cohort of low survival may have been in relatively poor condition and/or born later than usual, but sample sizes were too small for significance testing.

Antlers

Antler characteristics, especially of yearling males, were related to nutritional quality of the diet and physical condition in deer (French et al. 1956, McEwen et al. 1957, Robinette et al. 1973, and Rasmussen 1985). Hamlin and Mackie (1989) reported that antler measurements of yearling male mule deer accurately reflected forage conditions and fawn survival during years of extremes. Because of regulation type, we did not have unbiased measurements for antlers of yearling male elk during most years. Antler measurements of 2-year-old males were collected most consistently during all years.

Table 4.4. Mean diastema length in millimeters for female elk cohorts (birth year) as they aged, Gravelly-Snowcrest Mountains.

Cohort	Age										
	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5
1981									109.7		108.3
1982			96.8					106.0	104.4		
1983		100.9	98.7				105.8			110.3	108.9
1984	79.9	97.2	98.4			105.9	107.0	108.2	105.7		109.9
1985	81.7	99.0	100.8		103.1	105.3	107.9	107.4	109.9	107.4	
1986	80.7	101.1	100.1	101.5	104.6	105.8	106.8	106.9	106.7		
1987	83.9	100.1	99.0	102.4	105.9	104.2	106.1	106.8	110.9		
1988	82.0	99.0	98.5	102.7	105.1	105.3	106.0	106.9	109.6		
1989	81.4	99.6	99.0	101.2	104.4	104.7	107.9	108.6			
1990	84.0	100.5	99.8	102.4	104.2	104.6	104.7				
1991	82.4	100.5	100.7	103.4	103.8	105.2					
1992	81.7	100.0	98.4	102.6	103.7						
1993	81.7	101.1	98.8	102.4							
1994	82.0	99.8	98.9								
1995	82.3	99.5									
1996	82.2										
Mean	82.0	99.9	99.1	102.3	104.4	105.1	106.5	107.3	108.1	108.9	109.0
Years	13	13	13	8	8	8	8	7	7	2	3

Our data indicated that average number of points per antler side and percent of antlers ≥ 6 x 6 points increased through age 4 (Table 4.5). Too few known-age bulls ≥ 5 years old were measured to determine growth beyond 4 years. Wolfe (1983) indicated that number of points increased through 7 years old, though most of the increase had occurred by 5 years. He also found that antler weight, length, and circumference increased through age 10 (Wolfe 1983). We also found that antler length increased through age 7, though our samples were small after age 4 (Table 4.6). We did not have the original data for Vermejo Park necessary to conduct statistical tests, but antler lengths by age were consistently longer for the Gravelly-Snowcrest population than the Vermejo Park Ranch population in New Mexico (Table 4.6).

For hunter-reported antler characteristics, the percent of yearling bulls in the Gravelly-Snowcrest Mountains that was spikes (65.6%) was the lowest (percent branched was highest, 34.3%) among a selected group of elk hunting districts in Montana (Table 4.7). This percentage seems low for spikes for the Gravelly-Snowcrest Mountains, but was comparable on a relative basis to hunter reports for the other HDs. Hunter reports for number of points are maximal and often include points less than 1 inch long. Maximum percent spikes for radiocollared yearling bulls was 82 percent (18% branched). True branching rates of yearling bulls may lie somewhere between 18% and 34%. In either case, branching rates of yearling bull elk in the Gravelly-Snowcrest Mountains apparently were among the highest in Montana. If elk are similar to mule deer (Hamlin and Mackie 1989), the high branching rate should indicate good physical condition.

Table 4.5. Antler point characteristics by age for known-age or incisor-aged male elk, Gravelly-Snowcrest Mountains, 1984-1996. Only elk with both antlers present and non-deformed were included.

Antler points	Age			
	2.5	3.5	4.5	≥5.5
2 x 2	4 (0.5)[a]			
2 x 3	7 (0.9)			
3 x 3	18 (2.2)			
2 x 4	8 (1.0)			
3 x 4	66 (8.1)			
4 x 4	141 (17.4)	2 (1.8)	1 (3.1)	
3 x 5	22 (2.7)	3 (2.8)	0	1 (7.1)
4 x 5	172 (21.2)	10 (9.2)	0	1 (7.1)
5 x 5	301 (37.1)	46 (42.2)	6 (18.8)	1 (7.1)
4 x 6	6 (0.7)	1 (0.9)	0	0
5 x 6	43 (5.3)	17 (15.6)	5 (15.6)	1 (7.1)
6 x 6	23 (2.8)	28 (25.7)	18 (56.3)	8 (57.1)
5 x 7	0	0	1 (3.1)	0
6 x 7	1 (0.1)	1 (0.9)	1 (3.1)	2 (14.3)
7 x 7	0	1 (0.9)	0	0
Total	812	109	32	14
% >5 x 5	8.3	43.1	78.1	78.6
% ≥6 x 6	3.0	27.5	62.5	71.4
Mean pts./side	4.53	5.28	5.69	5.71

[a] Number(%).

Table 4.6. A comparison of mean antler length (mm) of bull elk by age between the Gravelly-Snowcrest Mountains and the Vermejo Park Ranch, New Mexico.

Age	Mean antler length (mm)	
	Gravelly-Snowcrest Mtns.	New Mexico (Wolfe 1983)
2	753(736)[a]	688(125)
3	876(109)	803(109)
4	1007(29)	925(104)
5	1027(7)	1013(51)
6	1146(2)	1085(37)
7	1250(1)	1189(34)

[a] Mean antler length in mm (number of bulls).

Table 4.7. Percent of spikes (1 x 1) reported by hunters in the SWHQ among bull elk with antler points ≤ 3 x 2 in selected hunting districts of Montana, 1985-1995.

Hunting Districts	*n*	% 1 x 1[a]
104[b],121,123,200,202	3,333	91.8
240	329	90.6
140,141,150,151	748	89.3
100	484	87.6
316,317,560	964	85.2
283,291,292	2,679	84.8
329,331,332	3,731	84.1
101,102,120,122,103[b]	1,158	83.7
411,412,447	121	81.8
204,250,261,270	1525	81.3
210,211,213,214,216	1,524	81.1
413,416,418,432,448,454,540	3,687	77.2
410,417,426,621,622,623,631,632,700	449	75.3
325,327[c]	**212**	**65.6**

[a] Of bull elk with antler points ≤ 3 x 2, % that were 1 x 1.

[b] 1990-1995 only, after split of HDs 103 and 104.

[c] 1985 and 1986 only, spikes illegal in a portion of HD 327 after that.

Of yearling male elk in the Gravelly-Snowcrest Mountains with branched antlers, 57.8% had ≥ 2 x 2 antler points and 2.7% had ≥ 3 x 4 antler points (Table 4.8).

Table 4.8. Antler point characteristics for yearling male elk with branched antlers, Gravelly-Snowcrest Mountains, 1984-96.

Antler points	Number	%
1 x 2	46	40.4
1 x 3	2	1.8
2 x 2	47	41.2
2 x 3	12	10.5
3 x 3	4	3.5
3 x 4	2	1.8
4 x 4	1	0.9
Total	114	100

We measured antlers of 33 known-age bull elk according to Boone and Crockett criteria (Table 4.9). Measurements for 2- and 3-year-old bulls were similar to those reported by DeSimone and Vore (1992) for the Elkhorn Mountains of Montana. Although our sample of 4-year-old bulls was limited, antlers scored much higher for bulls in the

Gravelly-Snowcrest than the Elkhorn population. The lowest score for 4 year olds in the Gravelly-Snowcrest Mountains was higher than the mean score for the Elkhorns.

Table 4.9. Mean Boone and Crockett score of bull elk antlers by age, Gravelly-Snowcrest Mountains, Montana.

Age	*n*	Gross Score	Range	Net Score	Range
2	18	183.26	147 5/8–206 3/8	171.90	134 0/8–201 7/8
3	10	223.20	182 1/8–256 4/8	216.93	177 6/8–251 4/8
4	5	283.05	267 5/8–309 5/8	275.15	257 7/8–305 2/8

Disease and Parasites

We submitted blood samples collected from 913 elk during capture operations to the Montana Department of Livestock Diagnostic Laboratory, Bozeman for disease testing. Four (0.44%) samples tested positive for brucellosis (Table 4.10). Three of the positive tests were from adult females equipped with radiocollars on the WCWMA in March 1988. After blood tests indicated a positive reaction for brucellosis, these 3 elk were located and shot. We prepared tissue samples from these elk and forwarded them to the National Veterinary Services Laboratory in Ames, Iowa for *Brucella* culture. *Brucella abortus* biovar I, not strain 19, was isolated from samples of all 3 elk, indicating infection. A seropositive result was also reported for a sample from a 9-month-old male calf captured at WCWMA during March 1995. Because results of the blood test were not reported until July, he was not collected.

Table 4.10. Positive reactions to tests for various livestock-wildlife diseases among blood samples of elk from the Gravelly-Snowcrest Mountains, 1984-1995.

Disease	*n*	No. (%) positive
Brucellosis	913	4(0.44)
Bluetongue	913	0(0.0)
Anaplasmosis	202	0(0.0)
Leptospirosis @ 1:50 dilution	909	183(20.1)
Leptospirosis @ 1:100 dilution	909	39(4.3)
Leptospirosis @ 1:200 dilution	909	3(0.33)
Infectious bovine rhinotracheitis	171	22(12.9)
Bovine viral diarrhea	166	112(67.5)
Parainfluenza 3	138	53(38.4)

None of 913 elk tested positive for bluetongue and none of 202 elk were positive for anaplasmosis. We considered only samples tested after 1991 with the card test valid for detection of anaplasmosis. Positive reactions for serovars of leptospirosis were reported for 20.1% of 909 elk at dilutions of 1:50, 4.3% at dilutions of 1:100, and 0.3% at dilutions of 1:200 (Table 4.10). Reactions at dilutions of less than 1:100 are unlikely to be significant. Reaction rates were 12.9% for infectious bovine rhinotracheitis, 67.5% for bovine viral diarrhea, and 38.4% for parainfluenza 3 (Table 4.10).

The occurrence and relative importance of various serovars among blood samples that were positive for leptospirosis (Table 4.11) indicated that serovars autumnalis, bratislava, and grippotyphosa were most likely to be important in this area.

Table 4.11. Relative frequency of serovars among elk with positive reactions in tests for leptospirosis, Gravelly-Snowcrest Mountains, 1984-1995.

Dilution	*n* elk(*n* serovars)	Serovar	Frequency among serovars
1:50	183(228)	autumnalis	26.3
		bratislava	24.1
		grippotyphosa	19.3
		icterohemorrhagia	15.4
		tarassovi	13.6
		hardjo	0.9
		pomona	0.4
1:100	31(33)	autumnalis	33.3
		bratislava	27.3
		grippotyphosa	24.2
		tarassovi	6.1
1:200	3(3)	autumnalis	100.0

Nothing in our results indicated that elk in the Gravelly-Snowcrest Mountains suffered major mortality or reproductive problems as a result of any of these diseases. The positive results for most of these diseases can mean only that elk have been exposed to the diseases and have developed antibodies against them. However, the 3 adult females with positive reactions to tests for brucellosis were confirmed to have active infections. These elk wintered on the WCWMA, a population from which 1-8.5% of radiocollared elk spent summer and autumn in or near Yellowstone National Park, where infection rates are highest locally. However, the elk were collected before they moved to their undetermined summer range. No elk from other Gravelly-Snowcrest populations tested positive for brucellosis. The low prevalence (0.4%) of antibodies to *B. abortus* in the Gravelly-Snowcrest populations was similar to populations in the Gallatin drainage (K. Aune, pers. com.). Prevalence in upper Madison and Northern Yellowstone populations was slightly higher at about 1% and prevalence in the Madison/Firehole population was about 3% (K. Aune, pers. com.). Prevalance for WCWMA female elk was 1.5% (3/201). Prevalence in all of these free-ranging populations was much lower than the 16-50% seroprevalence reported among 6 feedground herds in northwestern Wyoming (Herriges et al. 1992).

We collected fecal samples from 49 elk captured during early March 1994. Lungworm larvae (*Dictyocaulus viviparus*) were found in 21 (42.9%) of the samples. This frequency of occurrence is within the normal range for elk populations in this area at the peak of seasonal (Mar-May) incidence and intensity (Worley 1991). Lungworm larvae per gram ranged from 1-27 among positive samples. *Trichuris* spp. and *Haemonchus* spp. were detected in one sample each. The total parasite load for this sample of 49 elk was low. The prevalence and intensity of lungworm infection was low to moderate (K. Aune, pers. comm.).

Urinary Metabolite Ratios

Various urinary metabolite ratios have been proposed as indicators of nutritional level and body condition in ungulates (DelGiudice et al. 1988, DelGiudice et al. 1989, DelGiudice et al. 1991a and 1991b, Vagnoni et al 1996, Garrott et al. 1996, and Pils et al. 1999). For wild animals, these ratios were determined from analysis of urine excreted in snow. We collected samples of elk urine in snow during 1989, 1994, and 1995 to examine the potential of these ratios to determine condition of Montana elk. We also provided assistance and money for sample analysis for a portion of a graduate student study of allantoin : creatinine ratios (Pils et al. 1999). Analyses of samples for 1989 and 1994 were made for urea nitrogen : creatinine (U:C) and potassium : creatinine (K:C) ratios as proposed by DelGiudice et al. (1989). Samples for 1995 were analyzed for allantoin : creatinine ratio as proposed by Garrott et al. (1996).

We did not observe U:C ratios (Table 4.12) associated with severe starvation or catabolism of body protein (>20, DelGiudice et al 1991a). At the observed levels, ratios we obtained represented a higher nutritional quality of the diet (DelGiudice et al. 1989) than observed for naturally foraging elk of the Northern Range of YNP (DelGiudice et al. 1991b). During March 1989 (a severe winter), the mean U:C ratio (Table 4.12) at WCWMA was within the range observed for captive elk fed artificially high quality diets (2.3-4.4, DelGiudice et al. 1991a, 1991b). Also during 1989, at the time of collection, elk at the Wall Creek Wildlife Management Area may have had a higher quality diet than elk at Lodgepole Creek in the Gallatin drainage, near the northwestern edge of YNP (Table 4.12).

Urinary excretion of potassium is directly related to food intake (Keynes and Harrison 1967, DelGiudice et al. 1987, and Kopple 1988). Higher levels indicate greater forage intake. A higher rate of forage intake was indicated for elk at the WCWMA than for elk in the Gallatin drainage associated with YNP (Table 4.12). For comparable times during winter, elk at the WCWMA (Table 4.12) also may have had a higher rate of forage intake than elk on the Northern Range of YNP (DelGiudice et al. 1991b). These samples were not collected at the same time, in the same year, with a controlled, designed study, however, so are only suggestive, not definitive.

Table 4.12. Mean values for some urinary metabolite ratios in elk urine excreted in snow, collected at 2 areas in Montana.

Urinary metabolite ratios	Location[a]	Date		
		03-24/31-1989	02-14-1994	03-01-1994
U:C[b]	WCWMA	2.98(0.95-4.10)[c]	1.41(0.87-1.98)	1.81(0.64-3.00)
	Lodgepole Cr.	1.29(0.50-3.90)		
K:C[d]	WCWMA	13.3(2.6-47.3)	97.6(79.6-124.3)	
	Lodgepole Cr.	9.8(1.5-39.7)		

[a] WCWMA = Wall Creek Wildlife Management Area, Lodgepole Cr. is just outside the northwest corner of Yellowstone National Park.
[b] Urea nitrogen:creatinine.
[c] Mean (Range).
[d] Potassium:creatinine.

If, within the observed ranges, U:C and K:C ratios indicated diet quality, condition, and survival, the differences we observed between the WCWMA population and YNP populations followed an expected pattern. There appeared to be potential for these urinary metabolite ratios to index population nutritional status.

Potential problems and limitations have been identified for use of U:C and K:C ratios to index nutritional conditions (Parker et al. 1993, White et al. 1995a, b, and Garrott et al. 1996). We include the lack of clarity about determining when U:C ratios represent the high end of quality natural diets and when they represent early stages of body protein catabolism as a potential problem. If unequivocal determination is possible only for animals in late stages of starvation, U:C ratios have limited potential use.

Recently, others have investigated the efficacy of urinary allantoin:creatinine ratios (A:C) as a dietary index for elk. Vagnoni et al. (1996) established that a significant, positive relationship existed between digestible dry matter intake (DDMI) and A:C ratio in elk urine. This relationship was consistent with findings in sheep (Chen et al. 1992) and dairy cattle (Giesecke et al. 1994). The relationship appeared to be sensitive to moderate changes in nutritional input (Vagnoni et al. 1996), which addressed one of our concerns about U:C ratios. Garrott et al. (1996) and Pils et al. (1999) established the potential of the A:C ratio index for free-ranging elk from snow-urine samples and refined collection protocols and analytical techniques. A:C ratios represent forage values for recently consumed forage, they do not represent accumulated condition (Pils et al. 1999). Also, the trimmed A:C ratios were intended to represent adult cows, not calves (Pils et al. 1999).

Pils et al. (1999) provided comparisons of trend in A:C ratios among 5 elk populations over winter 1996-97. They suggested that interpopulation contrasts might not be appropriate and that the best use of these ratios might be to evaluate effects of habitat manipulations, quality of winter ranges, appropriate densities, or causes of poor recruitment. We believe, however, that potential does exist for interpopulation comparisons if baseline ranges of values are established for each population over a series of years of varying conditions. Figure 4.1 (after Pils et al. 1999) presents data for 5 elk populations during winter 1996-1997 and we include additional data from 3 samples we collected during 1994-1995. A:C values for elk populations at WCWMA and Hungry Horse, 2 naturally foraging Montana populations, and the supplementary fed National Elk Refuge population in Wyoming, were consistently higher than for 2 elk populations associated with YNP (Fig. 4.1). The 3 data points in Figure 3.1 that are additions to Figure 4 in Pils et al. (1999) were derived in the same manner as their data. They performed the assays and we calculated trimmed means as they did, deleting the largest 20% and smallest 15% of A:C ratios from the data set prior to calculation of means. Values for A:C at WCWMA for the same time period in winter were higher during the milder winter of 1994-1995 than the more severe winter of 1996-1997 (Fig. 4.1). This varying of A:C values with winter severity was also noted by Garrott et al. (1996). Although not documented by weather records, our impression was that snow cover was less persistent during 1994-1995 than 1996-1997.

The higher value of the A:C ratio for the BTWMA than for the WCWMA during the same time period also was interesting. As noted earlier, calf girth measurements were consistently larger at the BTWMA than the WCWMA. One difference in habitat management between the 2 areas is that cattle graze the WCWMA but not the BTWMA. As Pils et al. (1999) suggested, these data, by themselves, may not be valid for definitive interpopulation comparisons, but do illustrate several possible areas for further investigation. These include: 1.) Are A:C values consistently higher on the BTWMA than the WCWMA over a series of years? 2.) How do A:C ratios compare among a variety of Montana elk populations?, and 3.) Do these values relate to population performance (e.g., calf production and survival)?

Blood Chemistry and Hematology

The literature contains many articles examining the use of blood chemistry and hematology to monitor condition of various animal populations or health of individual animals. To date, there is little indication that blood parameters are useful in evaluating either condition of wild animals or population health. The body generally maintains homeostasis, with values for individual blood parameters deviating substantially from means only in extreme or life-threatening situations. General capture operations, such as ours, will usually capture only "average" to healthy animals. Unhealthy animals are usually undetected, not with other animals, or purposefully avoided during capture operations.

We analyzed parameters of blood collected from elk captured during 1984-1995. We present these data to establish "normal" value means and ranges for a generally healthy elk population. We also examined the effect of capture method, and sex and age of the elk on blood parameters. When these factors were accounted for, we examined blood parameters for relationships to population/individual health and nutrition. Many factors affected values and sample sizes varied among these covariates and among years, therefore we limited our statistical tests.

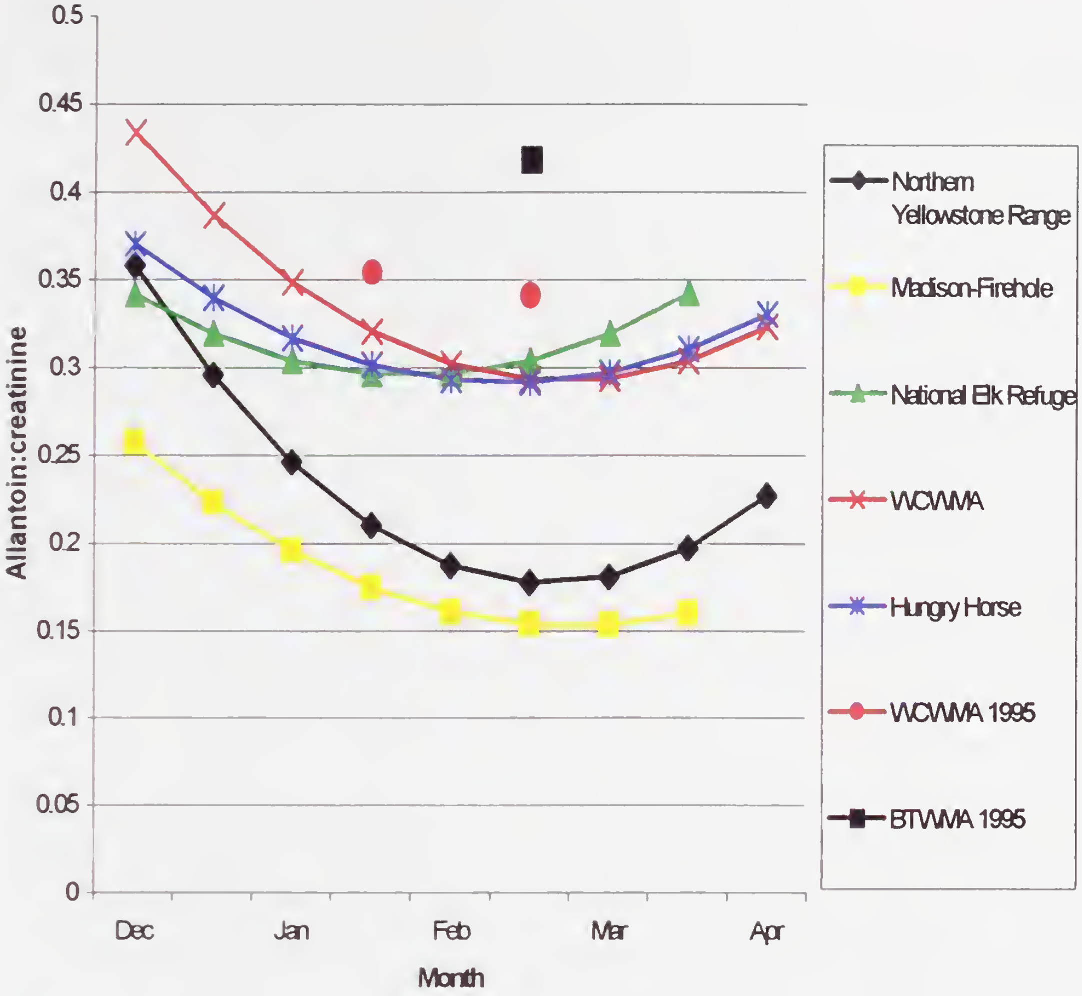


Figure 4.1. Predicted allantoin:creatinine (A:C) ratios derived from random sample collections for 5 free-ranging elk herds during 8 sampling periods from 14 December 1996 to 4 April 1997. For each sampling period, the largest 20% and the smallest 15% of A:C ratios were trimmed from the data set prior to analysis (from Pils et al. 1999). We overlay data from 3 samples for 1995 on their Figure.

Few adult males were captured, so we first compared mean values among female elk captured during late winter (Feb-Mar) by age category (Table 4.13). We present mean, maximum and minimum values, and standard deviations from the means for the various parameters for various sex/age categories in Appendix Tables A1-A8. Newborns were captured during June and were combined by sex (Table 4.13). Because of their age and the seasonal difference in capture time, values for newborns were not comparable to other age categories.

Table 4.13. Mean values for blood parameters of female elk by age, Gravelly-Snowcrest Mountains, 1984-1995.

Parameter[a]	Units	Age				
		Newborn[b]	9-10 Months	21-22 Months	33-34 Months	≥45 Months
BUN	mg/dl	17.24(68)[c]	20.53(212)	19.13(80)	18.10(42)	18.40(209)
TP	g/dl	5.68(68)	6.59(212)	6.96(80)	7.18(42)	7.17(209)
ALB	g/dl	2.97(68)	4.65(212)	4.75(80)	4.78(42)	4.72(209)
ALB/TP	%	52.9(68)	70.7(212)	68.4(80)	66.8(42)	66.3(209)
CA	mg/dl	11.40(68)	10.64(212)	10.76(80)	11.06(42)	10.97(209)
MG	mg/dl	2.33(68)	2.36(73)	2.43(47)	2.28(28)	2.39(171)
INP	mg/dl	10.28(68)	6.11(212)	5.57(80)	5.18(42)	5.27(209)
NA	meq/l	139.79(68)	143.23(73)	141.85(47)	143.36(28)	142.85(169)
K	meq/l	8.46(68)	16.15(73)	18.66(47)	16.89(28)	17.47(169)
ALKPHOS	IU/l	789.62(68)	152.89(210)	147.09(80)	195.45(42)	140.56(209)
TRIG	mg/dl	68.58(48)	51.12(65)	49.72(46)	51.96(24)	50.17(161)
CPK	IU/l		1217.68(147)	1000.74(34)	781.72(18)	632.08(48)
SGOT	IU/l	43.17(6)	127.41(147)	104.59(34)	116.94(18)	107.06(48)
GGT	IU/l		43.53(147)	33.62(34)	43.33(18)	43.08(48)
CREAT	mg/dl		3.45(146)	3.57(34)	3.63(18)	3.48(48)
TBILI	mg/dl		0.82(147)	0.68(34)	0.59(18)	0.48(48)
RBC	x10^6mm3	6.53(69)	10.86(205)	10.68(73)	10.46(40)	9.82(165)
MCV	μm^3	49.32(69)	49.04(205)	51.33(73)	53.45(40)	54.95(165)
HCT	%	32.12(69)	54.65(214)	55.15(80)	55.34(43)	53.25(203)
WBC	x10^3mm^3	5.41(69)	4.48(205)	5.14(73)	4.90(40)	5.17(165)
HGB	g/dl	10.75(69)	18.90(204)	19.46(73)	18.72(40)	18.81(165)
BANDS	x10^3mm^3	0.11(69)	0.04(205)	0.03(73)	0.03(40)	0.08(165)
SEGS	x10^3mm^3	3.10(69)	2.00(205)	2.25(73)	2.14(40)	2.36(165)
LYMP	x10^3mm^3	2.02(69)	2.12(205)	2.43(73)	2.32(40)	2.36(165)
MONO	x10^3mm^3	0.05(69)	0.02(205)	0.03(73)	0.02(40)	0.03(165)
EOS	x10^3mm^3	0.08(69)	0.29(205)	0.38(73)	0.36(40)	0.35(165)
BASO	x10^3mm^3	0.04(69)	0.03(205)	0.03(73)	0.03(40)	0.03(165)
N/L Ratio		1.91(69)	1.07(205)	1.07(73)	1.12(40)	1.20(165)
NRBC	#/100 WBC	7.95(60)	0.03(78)	0.02(45)	0.00(24)	0.01(125)
GLOB	g/dl	1.90(1)	1.89(60)	2.30(11)	2.42(13)	2.84(29)
PLT	x10^3mm^3		275.82(56)	281.82(17)	256.62(8)	247.59(17)
SGPT	IU/l		87.38(8)	70.0(1)	66.25(4)	65.80(10)
GLU	mg/dl		161.25(8)	161.0(1)	155.25(4)	171.50(10)
CL	μmol		103.25(8)	115.00(1)	108.50(4)	107.40(10)

[a] Explanation of abbreviations in Appendix Table B1.

[b] Newborn includes both sexes.

[c] Mean value (sample size).

Many of the differences in values of hematological parameters between newborns and older animals are explained by the immaturity of the hematological and skeletal systems of newborns. For example, higher values of newborns for inorganic phosphorus and alkaline phosphatase are probably related to active bone growth. Similarly, differences in values for whole blood parameters, including erythrocytes and leucocytes, are related to an immature hematological system. We did not find significant deviations in values among individuals, including calves that died from "starvation"/abandonment. Thus, the values reported here (Table 4.13) and the ranges and deviations (Appendix Table A1) should be considered a "normal" baseline of newborn elk.

Some values for blood parameters appeared to vary with age (Table 4.13) and we conducted 2-way ANOVA's of year and age (> newborn) with these parameters. Differences occurred for year (v1), but not age (v2), for blood urea nitrogen ($F_1 = 11.36$, $P < 0.001$, $F_2 = 1.34$, $P = 0.26$), inorganic phosphorus ($F_1 = 8.77$, $P < 0.001$, $F_2 = 2.03$, $P = 0.11$), and tbilirubin ($F_1 = 4.95$, $P = 0.002$, $F_2 = 1.10$, $P = 0.35$). We observed differences for both year and age for creatine phosphokinase ($F_1 = 2.87$, $P = 0.04$, $F_2 = 3.39$, $P = 0.02$), red blood cells ($F_1 = 52.6$, $P < 0.001$, $F_2 = 10.44$, $P < 0.001$), and mean corpuscular volume ($F_1 = 18.97$, $P < 0.001$, $F_2 = 46.7$, $P < 0.001$). Globulin was measured only in 1991, but differed among age categories ($F = 17.33$, $P < 0.001$). Time of year almost certainly affects values for blood parameters (Appendix Tables A2 and A3), but our data was limited for those tests. We use these results only to caution that some blood parameters may vary with age, even among elk older than 1 year old. Possibly, with larger sample sizes, some of the other parameters also may have varied significantly with age. Researchers who use blood values as variables may want to consider age as a covariate, or collect samples only among certain age categories.

During drive netting operations, some elk were driven several miles and many elk eventually captured and bled had been kept in an agitated state by "staging" for up to 6 hours. Once captured, these elk were handled quickly, time in the net and for processing was generally less than 15 min, often less than 10 min. Elk captured by drug immobilization were generally darted within 2 min of observation and processing time was generally less than 15 min. Because we moved from area to area, few elk were agitated for long periods before capture. We captured elk by net gun generally within 1-5 min of observation and processing time was generally less than 15 min. Again, we moved from area to area and few elk were agitated for long periods prior to capture.

Animals captured by physical restraint generally show hemoconcentration as stress and the capture technique result in a contraction of the spleen. This usually results in an increase in values of RBC, HGB, HCT, and TP (Wesson et al. 1979a, M. Johnson, DVM, pers. com.). Conversely, chemical immobilization may reduce stress level and hemoconcentration may be minimized (Wesson et al. 1979b) or hemodilution may even occur (Seal et al. 1972, Wesson et al. 1979a, M. Johnson, DVM, pers. com.). This may result in a decrease in values for RBC, HGB, HCT, and TP, especially as compared to animals captured by physical restraint. This would apply to narcotic drugs such as we used, but not neuromuscular blocking agents such as succinyl chloride. The neutrophil/lympocyte (N/L) ratio may also measure stress level, with a higher ratio indicating greater stress (J. Rhyan, DVM, pers. com.). Serum levels of CPK (CK, creatine kinase) may indicate muscle damage, strain, or possibly excitement level. Serum CK levels also may rise with exercise (Doxey 1983).

Calves were not captured in 1989, so only females ≥ 1 year old occurred in sufficient sample size to compare blood values among all years. We observed differences among values for RBC, HGB, HCT, and TP by capture techniques (ANOVAs, all $P \leq 0.001$). As discussed earlier, all values were lower for elk captured by drug immobilization than drive netting or net gunning (Sheffe tests, all $P \leq 0.001$, Table 4.14). These values may be normals for those captured by drug immobilization or may represent hemodilution. Values for net restrained elk probably represent hemoconcentration, compared to normal values. Values of TP and RBC were significantly higher for female elk captured by net gun than for both other techniques (Sheffe tests, all $P \leq 0.001$). This could indicate more straining against the net for net gun than for drive net capture.

For calves, we could only compare drive netting to net gunning as capture techniques. We observed no differences in values for TP and HCT between capture techniques (ANOVAs, all $P > 0.10$). Differences did occur for RBC and HGB (ANOVAs, all $P < 0.001$), but RBC was higher and HGB was lower (Sheffe tests, all $P < 0.002$) for net gun captured calves than drive net captured calves. In combination with the results for females ≥ 1 year old, we could not ascertain if hemoconcentration was different for drive net and net gun captured elk.

Values for creatinine kinase were not measured prior to 1990. However, for years after that, levels were significantly lower for both calves (Sheffe test, $P < 0.001$) and females ≥ 1 year old (Sheffe test, $P = 0.04$) captured by net gun than those captured by drive net (Table 4.14). This may indicate less muscle damage, stress, or less running over a long period of time (exercise) with use of net gun than drive net.

Similarly, N/L ratios were significantly lower for netgun captured calves than for drive net captured calves (Sheffe test, $P < 0.001$). An exception occurred for calves captured by drive net in 1987 for which N/L ratio was not different (Sheffe test, $P = 0.99$) than for calves captured by net gun (Table 4.14). The helicopter had a mechanical failure early during capture operations in 1987 and all captured elk had been “agitated” less than 2 hours. For female elk ≥ 1 year old, N/L ratios were significantly lower for those captured by net gun than those captured by drive net (Sheffe test, $P < 0.001$) except during 1987 (Sheffe test, $P = 0.96$). There were no significant differences in N/L ratio among female elk ≥ 1 year old captured by net gun, drug immobilization, or those captured by drive net in 1987 (Sheffe tests, all $P > 0.94$).

In combination, the blood value data for CK and the N/L ratio indicated that stress on elk may be greater when using the drive net capture technique than drug immobilization or net gunning. The anomaly of results for the 1987 drive net capture indicated that total length of time that animals are subject to disturbance probably is of most importance in measured stress level. Elk that were subjected to drive net activity for less than 2 hours time did not have N/L ratio values significantly higher than elk captured by net gun or drug immobilization.

Table 4.14. Mean values for elk blood parameters that may be affected by capture technique, Gravelly-Snowcrest Mountains, 1984-1995.[a]

Sex/age	Capture Technique	Blood Parameter[b]								
		RBC	TP	HCT	HGB	GGT	CREAT	TBILI	CPK	N/L Ratio
9 mo. old calves	Drive net w/o 1987	10.87a	6.59a	54.57a	18.85a	40.46a	3.51a	0.84a	1205.2a	1.08a
	1987 Drive net	11.07ab	6.46a	54.88a	20.18a					0.40b
	Net gun	12.12b	6.61a	55.77a	18.35b	88.82b	2.50b	0.19b	849.5b	0.38b
♀♀≥ 1 year old	Drive net	10.29a	7.19a	54.40a	19.38a	35.04a	3.68a	0.64a	850.3a	1.43a
	1987 Drive net	10.08a	6.92ab	55.36a	19.48ab					0.52b
	1989 Chem. Immob.[c]	8.87b	6.43b	49.25b						0.50b
	Net gun	11.44c	8.10c	57.53a	18.69b	67.53b	2.76b	0.16b	410.5b	0.30b

[a] Means in columns within the same sex/age category followed by the same letter were not significantly different at $P < 0.05$.

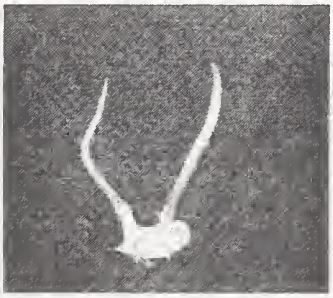
[b] Abbreviations and units for blood parameters same as for Table 4.13.

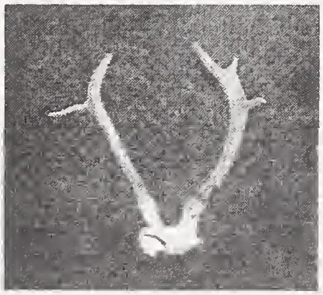
[c] Chemical immobilization – darting from helicopter – 2.7mg Carfentinal, 30 mg Xylazine.

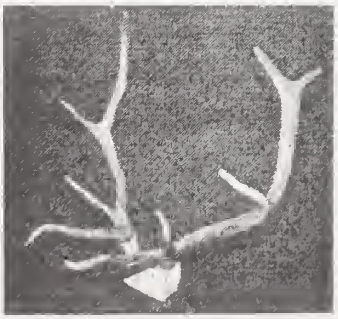
Biologists have long searched for blood parameters that would index nutritional condition of individuals and populations of ungulates (LeResche et al. 1974, Kirkpatrick et al. 1975, Franzmann and LeResche 1978, Seal and Hopkinson 1978, Seal et al. 1978a, 1978b, Kie et al. 1983, and Weber and Wolfe 1984). Results have been mixed, inconsistent, and nonrepeatable. We discussed some reasons for this at the beginning of this section. Additionally, as can be seen by the analysis conducted thus far, there are many covariates. Thus, even if reliable parameters for measuring population nutritional condition were known, a well-designed sampling system would be necessary for success.

Elk in the Gravelly-Snowcrest population have generally been considered to be in very good physical condition, with little difference among years. This further complicated attempts to determine blood parameters that might index condition. Only during 1995, the last year of collection, did measurable over winter mortality of calves occur. Therefore, we used blood values for 1995 as potentially representative of the worst nutritional condition of elk during the period. We also examined the blood profile of 4 elk calves that died after capture during winter 1994-1995 and that had < 20% fat content of femur marrow at time of death.

We could not find blood parameters that were consistently different in 1995 compared to other years, either among samples for the population or for those calves that died with low marrow fat reserves. Our results do not give optimism for use of blood parameters to measure nutritional status of free-ranging elk populations, especially considering other factors that affect values. Similarly, Cook et al (2001) did not find serum values that adequately represented nutritional condition in elk.


Spike (Yearling)


Branch-antlered Bull
(Yearling) - BAB


Brow-tined Bull
BTB

CHAPTER 5

POPULATION NUMBERS

Trend Counts

For trend counts, we defined populations by winter range locations of elk. Counting units were developed and delineated over many years, going back to the 1940s and were refined more recently by use of radio-telemetry. Some counting units listed in Table 5.1 such as the Blacktail and Robb-Ledford WMAs could be separated but are listed as a combined unit here because of possible overlap of animals at the boundaries of the areas. We present these areas separately in some analyses. Counting units such as the South Centennial Valley and North Centennial Valley might be combined with the Little Sage-Basin Creek and BTWMA units, respectively. However, displaying them separately allows viewing the effect of mild winters or early counts. Data displayed in Table 5.1 and subsequent Figures are the result of single (in most cases) trend flights.

Taking into account that some areas with few elk were not flown during early years of the study, counted elk numbers increased steadily on the study area during 1984-2000 (Table 5.1). For perspective, trend counts are best examined over a series of years rather than from year-to-year and perhaps best displayed graphically. Trend for the entire Gravelly-Snowcrest population indicated a population that grew at an exponential rate of increase of $r = 0.052$ (annual $\lambda = 1.053$) during 1985-2000 (Figure 5.1). Explanation of r and λ and methods of calculation were provided by Caughley (1977). We observed maximum growth during 1986-1997 with an exponential rate of change of $r = 0.085$ (annual $\lambda = 1.089$). This information also indicated that population growth may have stabilized during 1994-1995 to 1999-2000 (Fig. 5.1, Table 5.1). Less than ideal counting conditions during 1997-1999, however, may mean that growth was not as low as portrayed during this period. Change in numbers varied considerably by area (Table 5.1). Variation in rate of population change by time period for areas that were surveyed consistently after 1977 (Table 5.2) indicated that the Basin-Sage Creek population grew at only slightly less than the maximum rate that would be expected without hunting. In contrast, elk populations on the BTWMA, Cherry-Morgan, and Greenhorn-Upper Ruby areas were nearly stable over the 1985-1999 period (Table 5.2).

These observed differences were consistent with differences in hunting pressure among the areas. In conjunction with elk distribution during the hunting season, number of antlerless permits issued by MFWP by hunting district, and natural hunter distribution, hunting pressure was heaviest for the populations indicating stability during 1985-1999. Lack of vehicular access and greater natural hiding cover resulted in lower harvest rates for the majority of the population wintering on the WCWMA. Much of the population wintering on the Basin-Sage Creek area was in Idaho, where it was lightly hunted, during most of Montana's hunting season. Unless severe weather triggered movement to winter ranges early during Montana's hunting season, few of the elk spending winter on the Basin-Sage Creek area were subject to significant hunting pressure. Substantial numbers of antlerless permits for any hunting district only began to be issued after 1982.

Table 5.1. Aerial trend counts of elk for winters 1984-1985 through 1999-2000, Gravelly-Snowcrest Mountains.

Counting area	**1984-1985**	**1985-1986**	**1986-1987**	**1987-1988**	**1988-1989**	**1989-1990**	**1990-1991[a]**	**1991-1992**
Trail-Moran Creeks	33	97	80	14	0	0	114	218
Cherry-Morgan Creeks	414	150	623	333	260	512	444	791
WCWMA & vicinity	664	805	1,233	1,182	1,401	880	1,249	1,373[b]
Missouri Flats-W.F. Mad.	-[d]	35	134	142	91	157	162	32
Total E. side Gravellys	1,111	1,087	2,070	1,671	1,752	1,549	1,969	2,414[b]
North Centennial Valley	57	19	62	57	0	0	0	0
South Centennial Valley	119	-[d]	-[d]	-[d]	-[d]	310	93	71
BTWMA & RLWMA	1,740	1,473	1,403	1,663	1,820	2,719	1,918	2,517[h]
Greenhorns-Lower Ruby	576	383	432	463	317	458	41[illegible]	514
Little Sage-Basin Creeks	190	199	365	322	490	537	44[illegible]	840[j]
Blacktail Ridge	147	180	189	273	425	493	284	815[l]
Sweetwater Hills	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	145
Total Westside areas	2,829	2,254	2,451	2,778	3,052	4,517	3,155	4,902
GRAND TOTAL	**3,940**	**3,341**	**4,521**	**4,449**	**4,804**	**6,066**	**5,124[a]**	**7,316[m]**
	1992-1993	**1993-1994[a]**	**1994-1995**	**1995-1996**	**1996-1997**	**1997-1998[a,o]**	**1998-1999[o]**	**1999-2000[o]**
Trail-Moran Creeks	226	194	126	126	111	101	101	78
Cherry-Morgan Creeks	717	529	533	337	453	341	470	367
WCWMA & vicinity	1,343	1,591	2,002	1,594	2,264[c]	1,637	1,848	2,344
Missouri Flats-W.F. Mad.	123	77[e]	52	292	25	52	5[f]	-
Total E. side Gravellys	2,409	2,391	2,713	2,349	2,853[c]	2,131	2,424	2,789
North Centennial Valley	0	0	191	308	99	212	-[d]	57
South Centennial Valley	27	401[g]	82	233	-[d]	155	-[d]	276
BTWMA & RLWMA	2,510	2,045	2,457[i]	2,596	2,790	2,685	2,541	2664
Greenhorns-Lower Ruby	512	276	567	393	645	440	570	575
Little Sage-Basin Creeks	756	546	1,463[k]	1,283	1,305	1,625	2,055	1,635
Blacktail Ridge	933	359	595	534	731	427	377	454
Sweetwater Hills	98	116	93	0	118	116	56	99
Total Westside areas	4,836	3,743	5,448	5,347	5,688	5,660	5,599	5,760
GRAND TOTAL	**7,245**	**6,134[a]**	**8,161[n]**	**7,696**	**8,541[cn]**	**7,791[a]**	**8,023**	**8,549**

[a] Because of widespread distribution during winter, a greater than usual portion of elk were missed during aerial counts.

[b] A group of 477 elk counted near Wall Canyon were not included because we believed they had moved from the Sun Ranch in response to an ongoing late hunt.

[c] Perhaps some elk from the Sun Ranch were on the WCWMA at this time. Subsequent counts ranged from 1,796-1,965 on the WCWMA while counts on other east side Gravelly winter ranges were stable. The comparative total count would be 8,242 if 1,965 was used for the WCWMA.

[d] No flights were made over these areas.

[e] On 03-20-94, C. Fager counted 233 elk here.

[f] Incomplete count.

[g] Of these, 77 were in Idaho. These elk are in Basin-Sage Creeks during "normal" winters.

[h] This total includes 319 elk believed missed during the first flight and observed on a re-flight.

[i] Includes 126 elk in the area Piute Creek to Middle Fork of Blacktail Creek (normally on BTWMA).

[j] We counted 968 elk here on 12-20-91 with none observed in the Centennial Valley.

[k] Probably includes elk normally in the South Centennial Valley and on Blacktail Ridge.

[l] Of these, 109 observed in Price Canyon may be Basin-Sage Creek elk based on a marked elk observed.

[m] Depending on possible groups missed and extra elk from Sun Ranch the total could be 6,997-7,793 elk.

[n] Exceptionally favorable counting conditions, especially compared to 1990-91 and 1993-94.

[o] Flights by Bob Brannon.

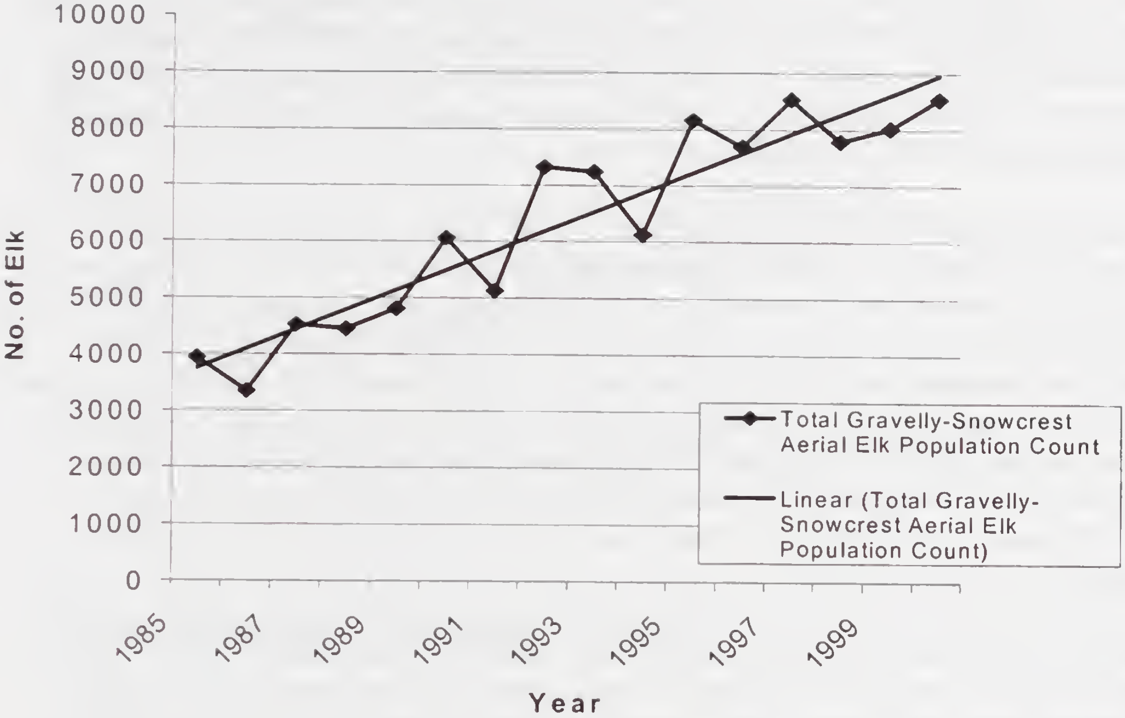


Figure 5.1. Total aerial elk population count, Gravelly-Snowcrest Mountains, 1985-2000.

Table 5.2. Exponential rate of change (r) in trend counts for elk populations in the Gravelly-Snowcrest complex during 1978-1999.

Time period	Location[a]							
	WC WMA	RL WMA	BT WMA	BT & RL WMAs	Cherry-Morgan	Greenhorn-Upper Ruby	Basin-Sage Creek	Blacktail Ridge
1978-1999	0.043	0.044	0.032	0.036	0.030	0.022	0.109	0.058
1985-1999	0.073	0.037	-0.002	0.009	0.009	-0.001	0.170	0.067

[a] WMA= Wildlife Management Area, WC = Wall Cr., RL= Robb-Ledford, BT= Blacktail.

Aerial trend counts have been conducted on some areas since 1947. Although the accuracy of any one of these flights is questionable, trend over the entire period is useful information. Following, we display and discuss trend for individual areas over the entire period for which data were collected.

East side of the Gravelly Range and WCWMA

For the entire period, 1947-2000, observed elk numbers on the WCWMA (Fig. 5.2) increased at r = 0.062 (annual λ = 1.063). For the period 1950-1962, the rate of increase for the elk population was r = 0.053 (annual λ = 1.054), a little below the average for the entire period. During 1962-1971, just after MFWP acquired the WCWMA, counts increased at r = 0.082 (annual λ = 1.086). Growth rate was slower from 1971-1983 and 1983-1995 at r = 0.047 (annual λ = 1.048) and 0.051 (annual λ = 1.052), respectively. Population growth may have slowed after 1995.

The entire east side of the Gravellys includes the WCWMA, Trail-Moran, Cherry-Morgan, W. F. Madison, and Sheep Creek-Mile Creek (Missouri Flats) wintering areas. Counts for this entire area increased at r = 0.055 (annual λ = 1.056) during 1950-2000, slightly less than for the WCWMA. Trend count for the Cherry-Morgan Creek area increased at an annual rate of r = 0.106 (annual λ = 1.112) from 1963-1992 (Fig. 5.3), but declined at an annual rate of r = - 0.096 (annual λ = 0.909) thereafter. This winter range is on private land and some increased hunting pressure has been directed toward this population in HD 330 recently. At least some elk may use both the WCWMA and Cherry-Morgan Creeks and some of these may also have shifted to the WCWMA recently.

Wildlife Area Manager Fred King made weekly counts from the ground of elk wintering on the WCWMA each year. We compared these repeated ground counts to our aerial trend survey count each winter. Timing was important for both types of counts. Early or late counts with either technique did not record peak numbers using the area (Figs. 5.4 – 5.14). Similarly, weather conditions on the day of the count have a major impact. This was not a major problem with aerial surveys because we chose the better days to fly. Some of the ground counts were conducted on unfavorable days for observation, however, and this should be taken into account when examining the data. Arrival of elk on the winter range depended on population segment (where they spent summer and autumn) and timing and severity of winter. Counts made during February and early March were apparently best to record maximum numbers on the winter range. When flights were made during relatively mild winters, data for the entire east slope of the Gravellys were more representative. These counts included elk on transitional range to the south that normally would be on the WCWMA.

Except for 1989-1990 (Fig. 5.7) when we missed a group of about 200 elk on our aerial trend survey of the WCWMA, we counted from the air about 110% (range, 103-121%) of the elk observed on the highest ground count that was near the same day. The close agreement of the 2 types of counts and the consistency of aerial counts being slightly higher than ground counts strengthened our conviction that our trend flight counts were generally near the total number of elk for the major wintering areas. Counts for the large groups were similar and aerial counts generally added smaller groups near the fringes of the winter range and those topographically hidden from surveys conducted from the ground. The results of the repeated ground counts compared to the aerial trend count

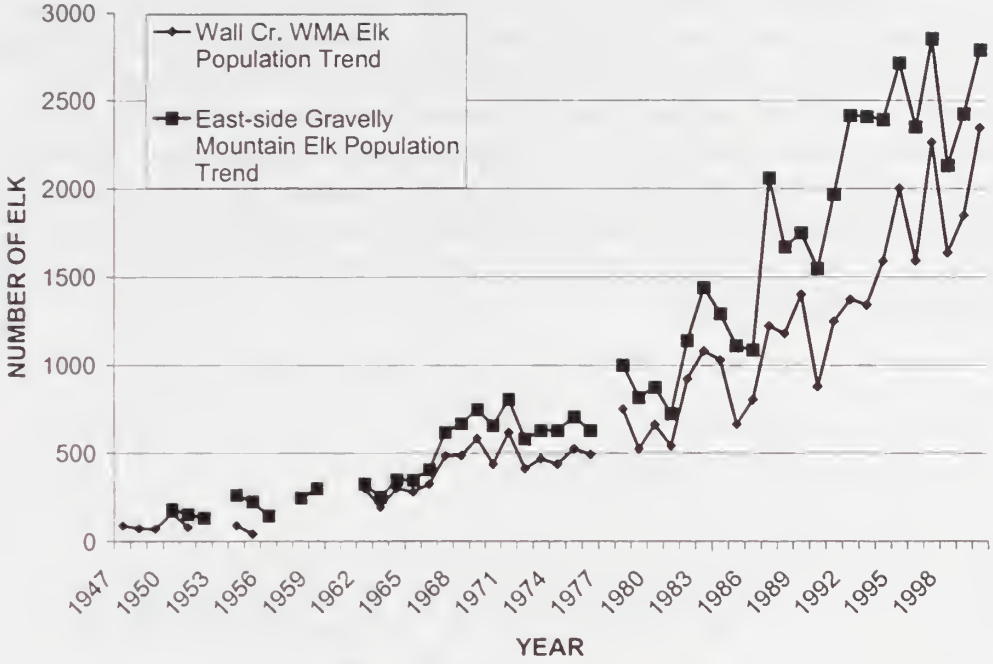


Figure 5.2. Aerial elk population trend counts for the Wall Creek Wildlife Management Area and East-side Gravelly Mountains, 1947-2000.

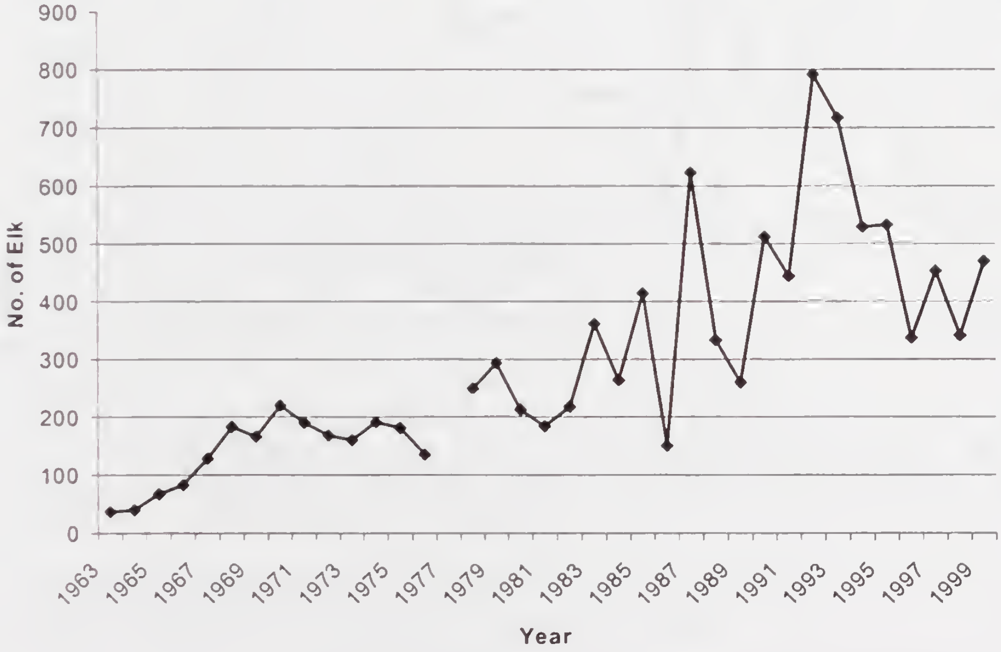


Figure 5.3. Aerial elk population trend counts for the Cherry-Morgan Creeks area, 1963-2000.

(Figs. 5.4 – 5.14), indicated to us that we did not usually miss large numbers of elk on our flights over the large open winter ranges. Obviously, some groups were occasionally undetected by both surveys and a higher proportion of elk were likely undetected on transitional ranges and on the smaller, more timbered winter ranges. Similarly, during mild winters, some elk were in Idaho and on transitional ranges in Montana that were not covered by our trend count flights. Elk in those areas likely represented the major portion of the population underestimated by aerial trend counts. Discrepancies such as those of 1996-1997 (Fig. 5.14) may have been due to elk from the east side of the Madison River temporarily moving to the WCWMA.

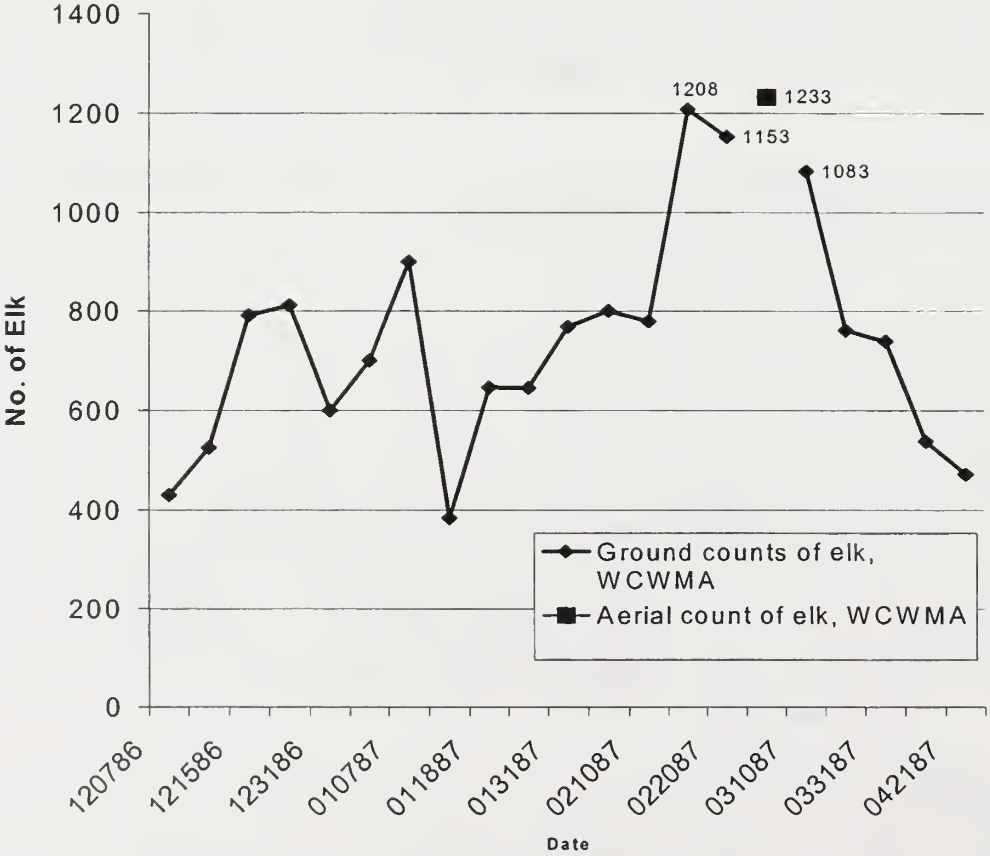


Figure 5.4. Ground and aerial counts of elk, WCWMA, 1986-1987.

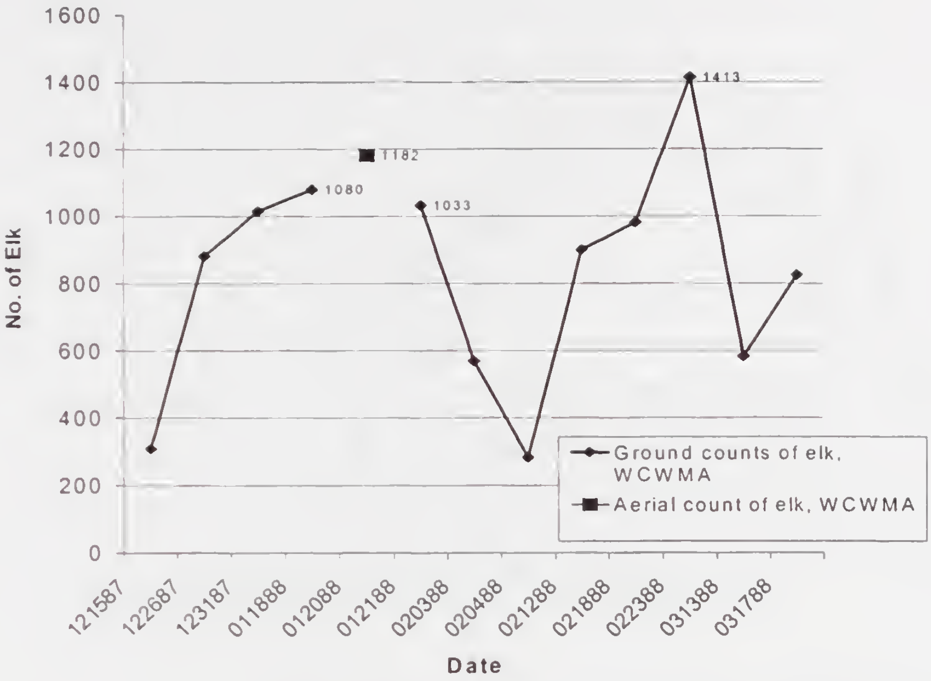


Figure 5.5. Ground and aerial counts of elk, WCWMA, 1987-1988.

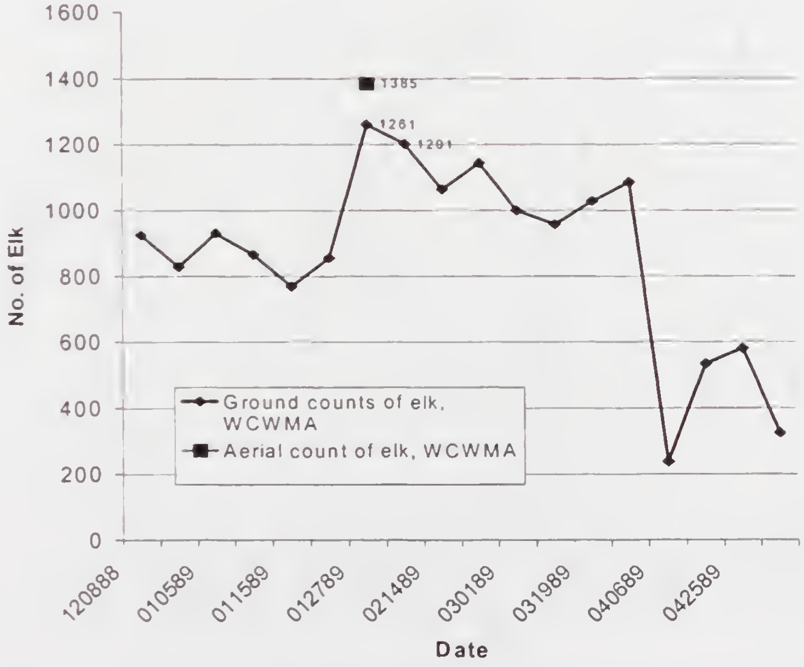


Figure 5.6. Ground and aerial counts of elk, WCWMA, 1988-1989.

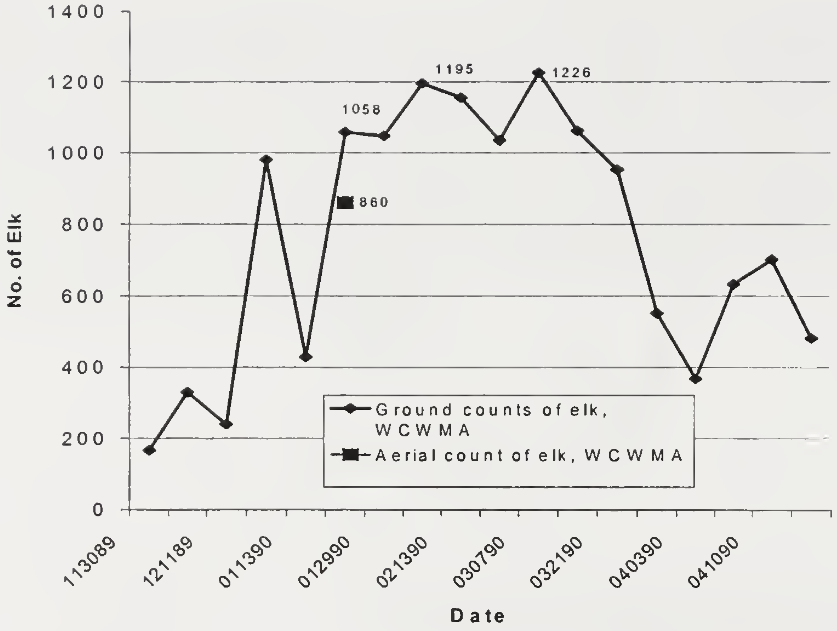


Figure 5.7. Ground and aerial counts of elk, WCWMA, 1989-1990.

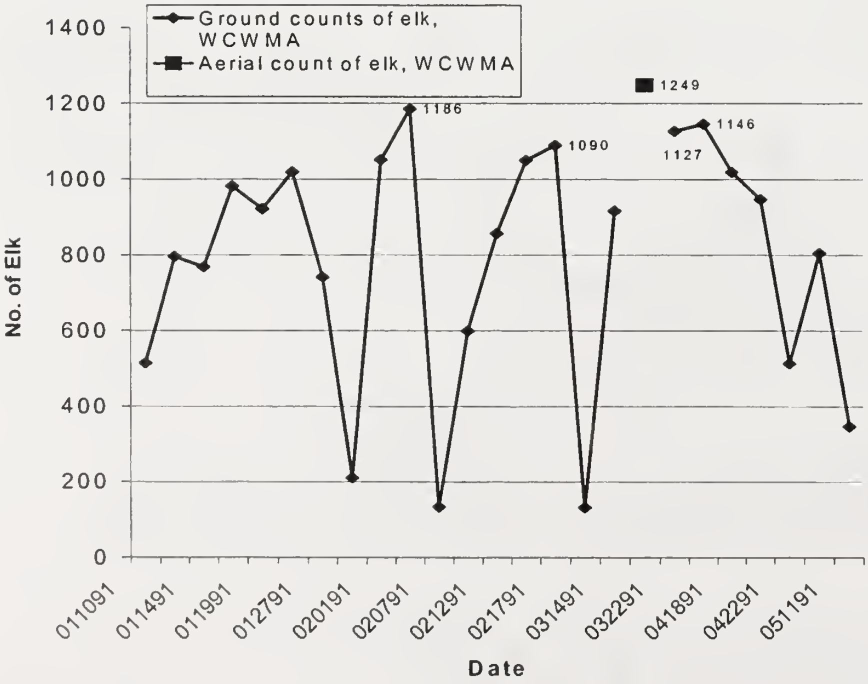


Figure 5.8. Ground and aerial counts of elk, WCWMA, 1990-1991.

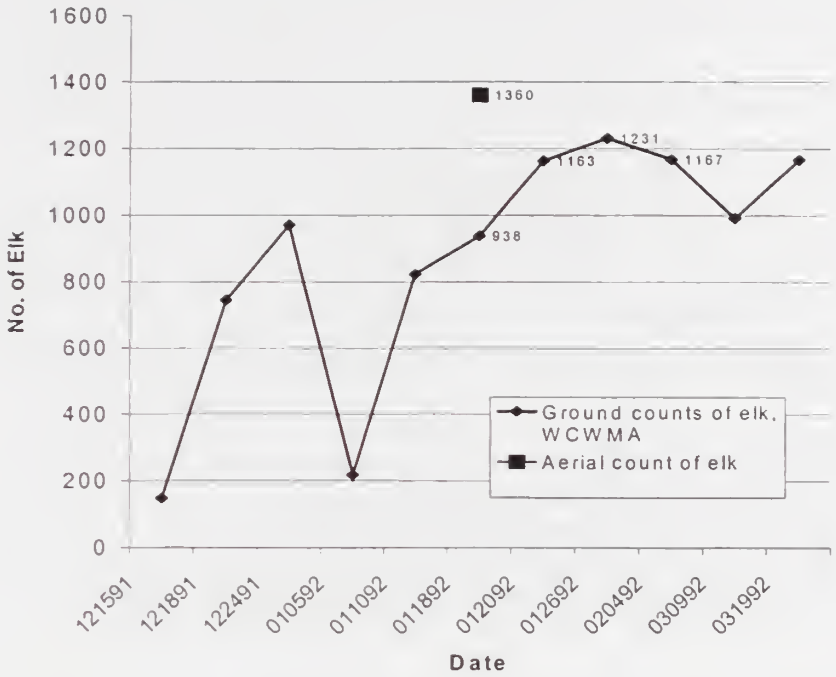


Figure 5.9. Ground and aerial counts of elk, WCWMA, 1991-1992.

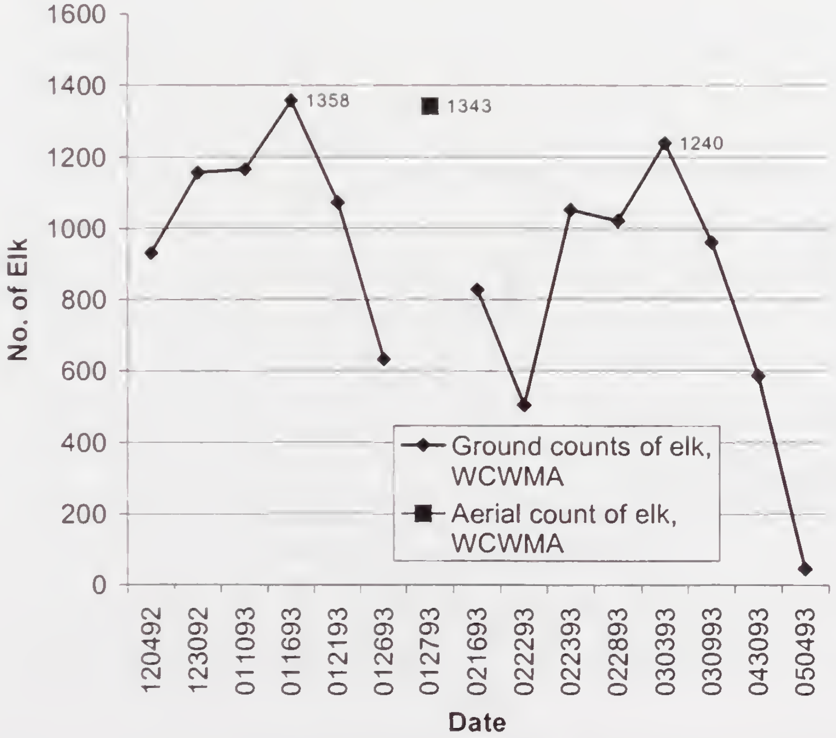


Figure 5.10. Ground and aerial counts of elk, WCWMA, 1992-1993.

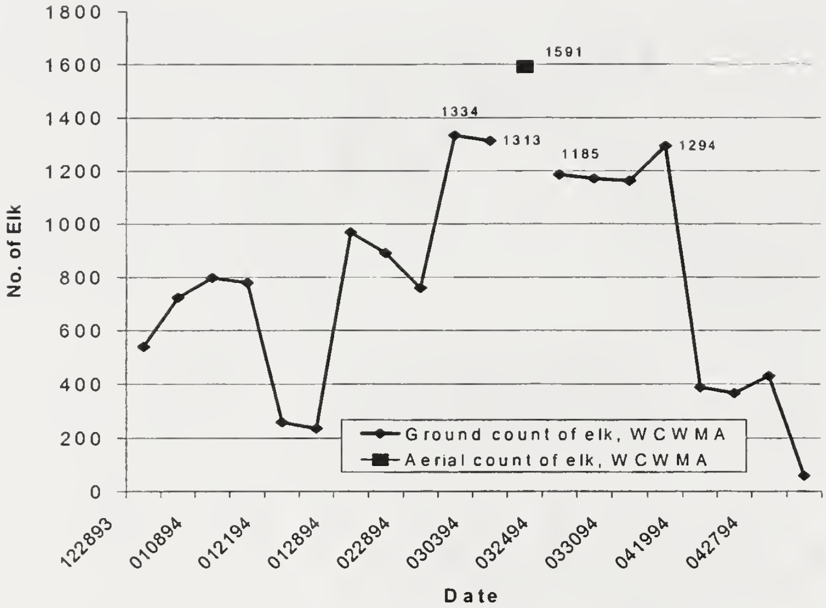


Figure 5.11. Ground and aerial counts of elk, WCWMA, 1993-1994.

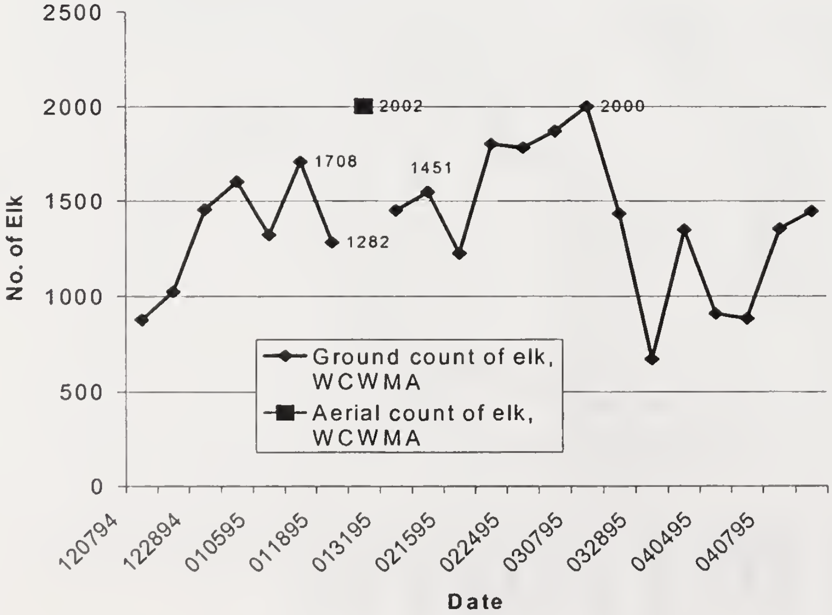


Figure 5.12. Ground and aerial counts of elk, WCWMA, 1994-1995.

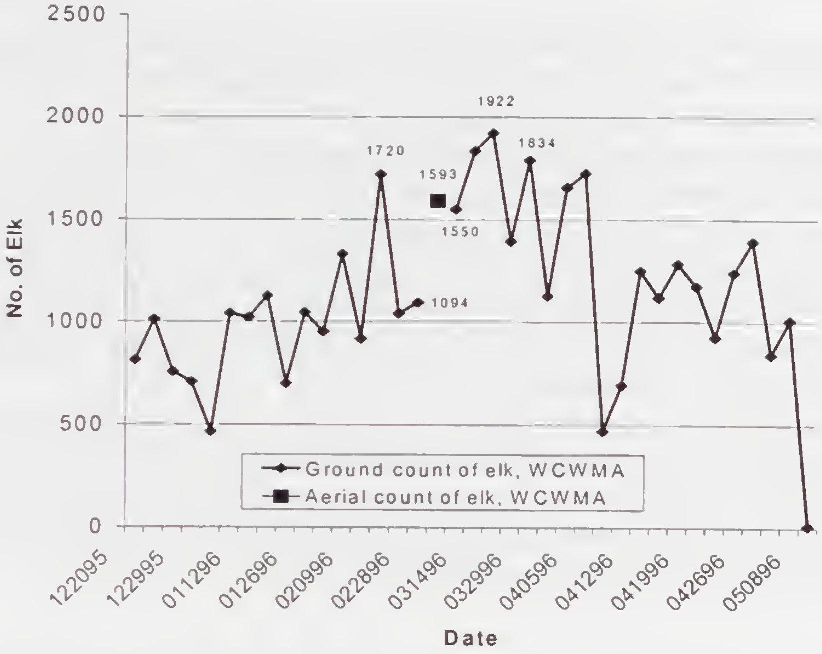


Figure 5.13. Ground and aerial counts of elk, WCWMA, 1995-1996.

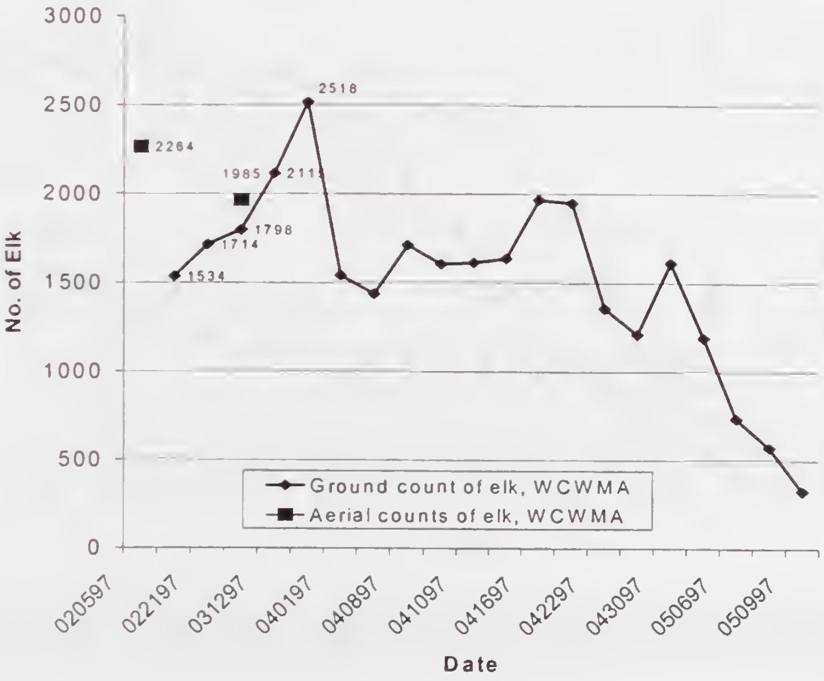


Figure 5.14. Ground and aerial counts of elk, WCWMA, 1996-1997.

Blacktail and Robb-Ledford WMAs

Population counts were relatively stable, given some annual variation, between 1948 and 1974, near the time when MFWP assumed ownership of the area (Fig. 5.15). There may have been a decline in the population between 1963 and 1966, however. During the period immediately after MFWP assumed ownership of the BTWMA (1974-1982), the number of elk observed on trend counts increased at r = 0.128 (annual λ = 1.137). On the nearby area that is now the Robb-Ledford WMA, counts increased at r = 0.044 (annual λ = 1.045). The RLWMA was mostly private land at that time. The elk population (trend count) on the BTWMA was relatively stable between 1982 and 2000. Low counts during 1986-1989 may have been related to unfavorable counting conditions. However, during 1982-2000, counts on the RLWMA increased at r = 0.048 (annual λ = 1.049). An example of the effect of missing several large groups of elk on the trend flight occurred in 1995 on the RLWMA (Fig. 5.15). An example of incorrectly assigning a group or two of elk on the boundary of population units to the wrong population may have occurred in 1998 (Fig. 5.15) when the count on the BTWMA spiked up and that on RLWMA spiked down. The reverse situation may have occurred in 2000 (Fig. 5.15).

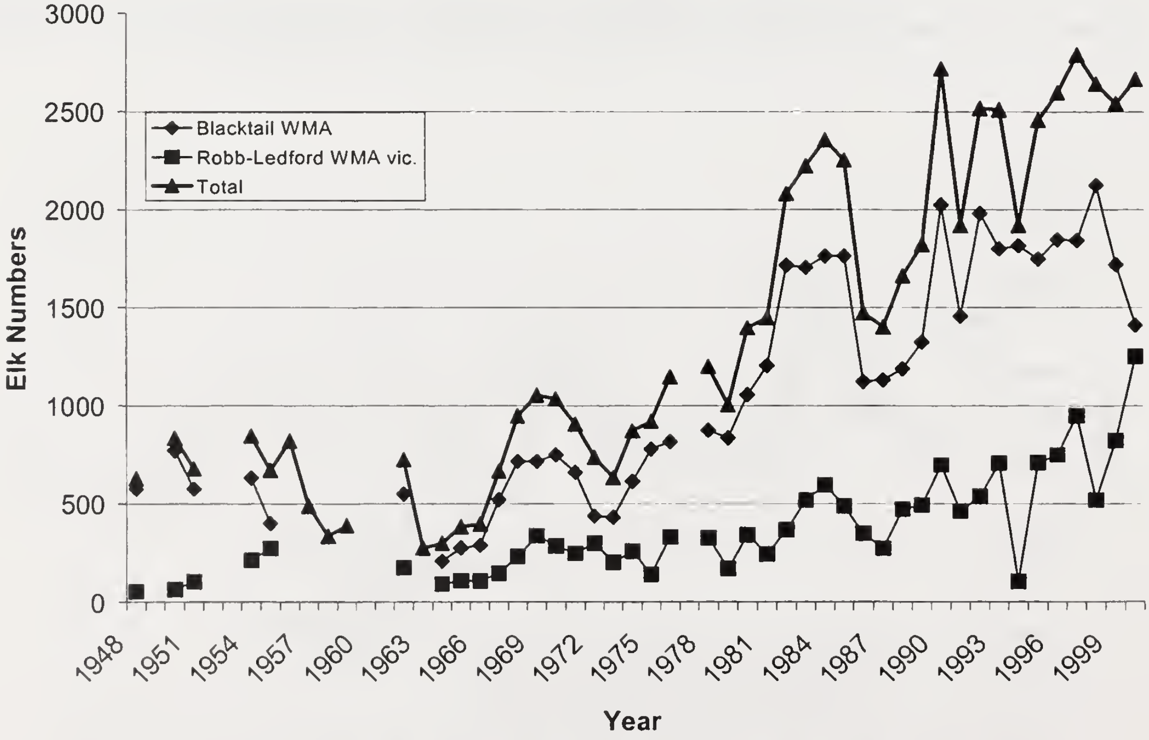


Figure 5.15. Aerial elk population trend counts on the BTWMA and RLWMA vicinities, 1948-2000.

Regular interchange between portions of the BTWMA and RLWMA populations was a problem for separating counts for these 2 areas. The two preceding examples illustrate some reasons why single trend counts are best viewed over a series of years rather than year-to-year.

Greenhorn – Upper Ruby

Elk wintering in the southwestern portion of the Greenhorn Mountains and in the Warmsprings Creek area of the Upper Ruby River intermingle. Therefore, we combined counts of the Greenhorn and Upper Ruby areas. Trend counts appeared to indicate 3 general levels of population status during 1958-2000 (Fig. 5.16). Periods of similar population size were 1958-1965, 1966-1982, and 1983-2000. Fluctuations occurred during each period, but probably were related to minor population changes and variable weather and counting conditions among years. Rate of increase for the entire period was $r = 0.032$ (annual $\lambda = 1.033$) and $r = 0.015$ (annual $\lambda = 1.015$) for 1980-2000. This area receives relatively heavy hunting pressure because of its geographic location. However, the western portion of the Greenhorns and the northeast face of the Gravellys receive less effective hunting pressure because of limited hunter access.

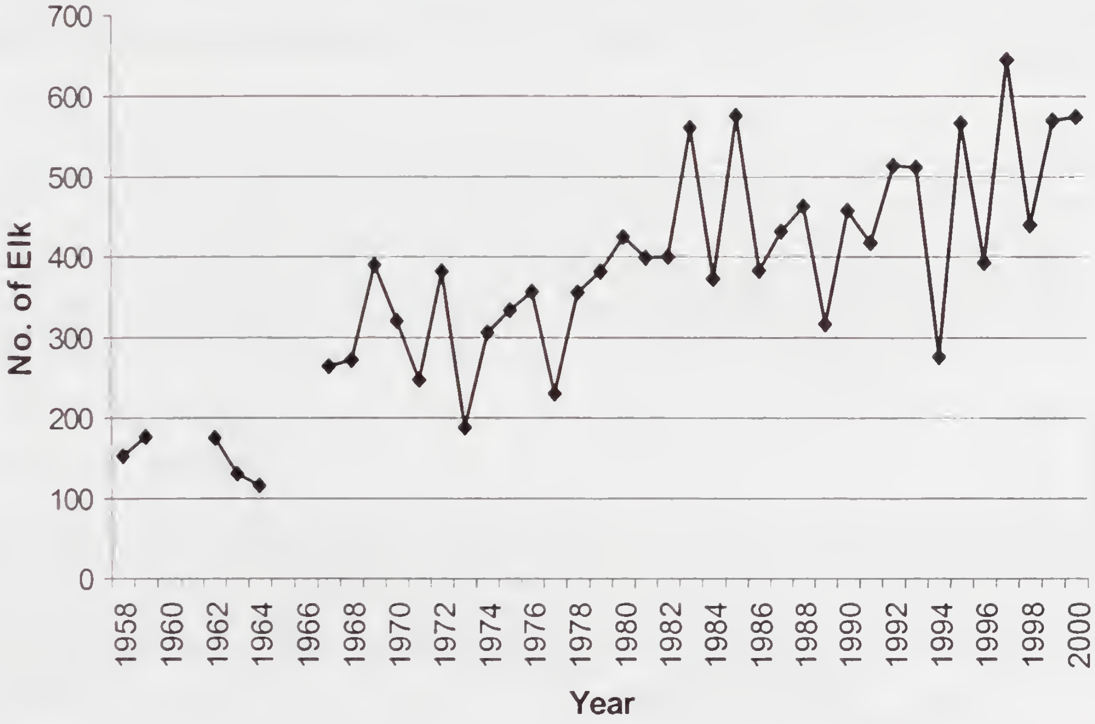


Figure 5.16. Aerial elk population trend counts, Greenhorn-Upper Ruby, 1958-2000.

HD 325 – Basin-Sage Creek and Blacktail Ridge-Clark Canyon Areas

Elk populations wintering in this HD were comprised of 4 counting units and probably 2 population units. Data were not collected consistently throughout the period for the South Centennial and Clark Canyon counting units (Figs. 5.17 and 5.18). Limited information from telemetry indicated that the South Centennial unit contained elk that were part of the Basin-Sage Creek population, but that remained in the South Centennial, or even in Idaho during relatively mild winter conditions. Similar limited information from telemetry indicated that at least some elk on the north to northwest end of Blacktail Ridge intermingled between Blacktail Ridge and Clark Canyon counting units. Some elk on the southern portion of Blacktail Ridge also may possibly have been part of either the Blacktail Ridge segment or the Basin-Sage Creek unit.

The observed rate of change for trend counts for the Basin-Sage Creek population was r = 0.109 (annual λ = 1.115) for 1978-1999 and r = 0.170 (annual λ = 1.185) for 1985-1999 (Table 5.2, Fig. 5.17). This was the fastest growing population in the Gravelly-Snowcrest complex. Telemetry data indicated that much of this population remained in the Camas Valley of Idaho during Montana's hunting season, especially during mild to average autumn weather. This influenced the higher growth rate within this unit. Control of this population will be difficult without heavier harvests in Idaho and/or late hunting seasons in Montana.

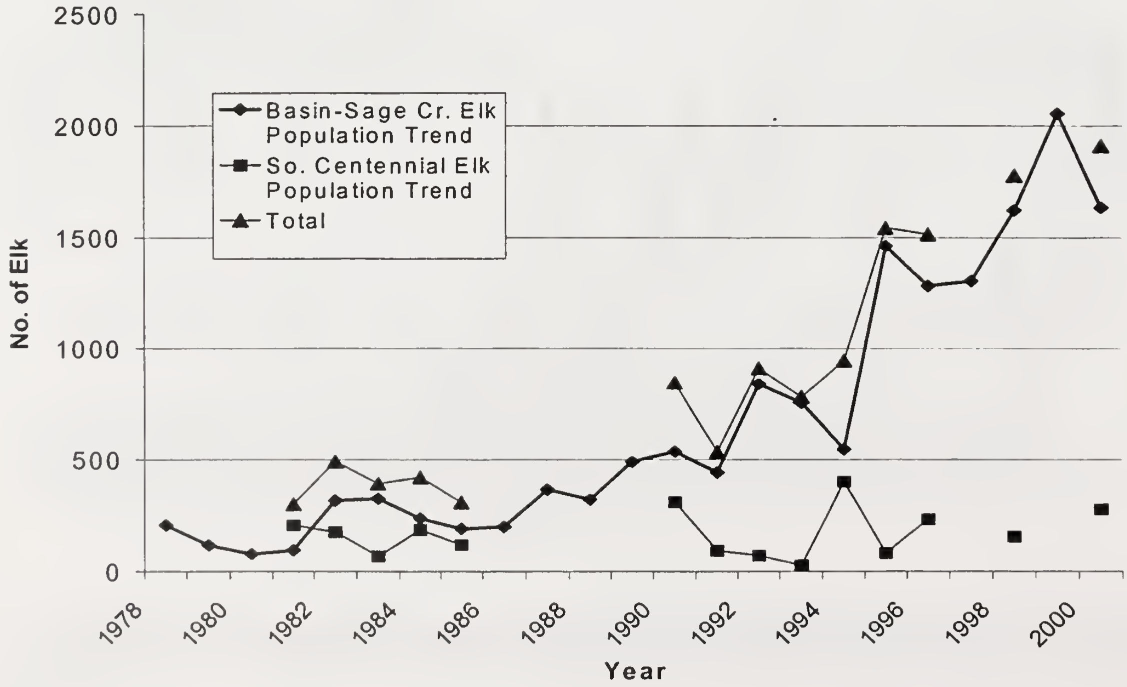


Figure 5.17. Aerial elk trend counts, Basin-Sage Creek and South Centennial, 1978-2000.

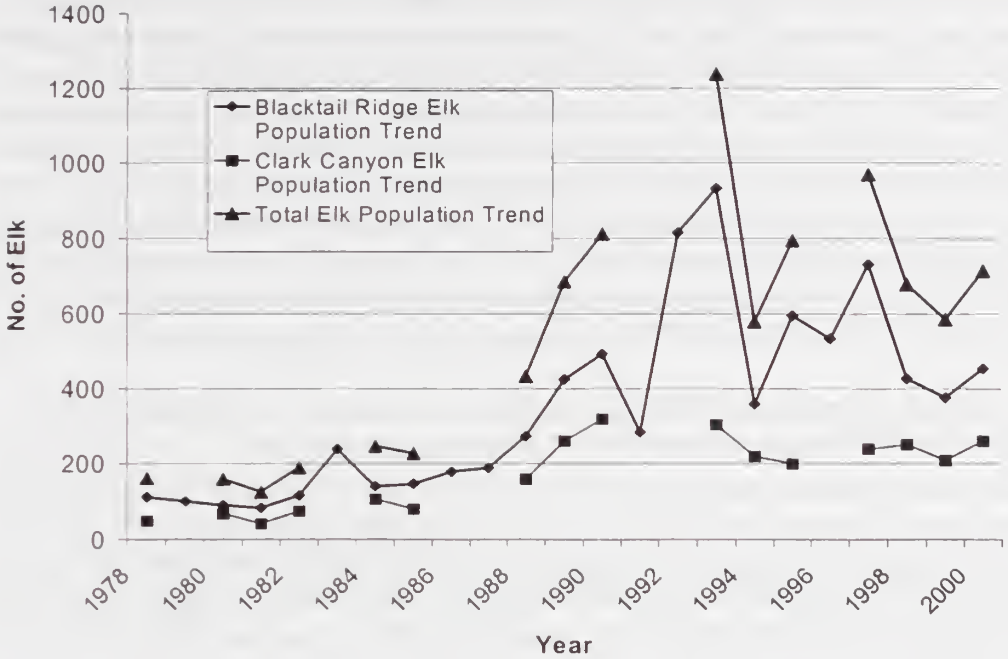


Figure 5.18. Aerial elk trend counts, Blacktail Ridge and Clark Canyon, 1978-2000.

Trend counts for the Blacktail Ridge population grew at r = 0.099 (annual $\lambda = 1.104$) during 1978-1997 (Fig. 5.18). The population appeared to decline after 1997. Elk from this population were generally distributed within HD 325 during the hunting season and thus, subject to higher hunting pressure than elk of the Basin-Sage Creek population. Success rate of antlerless permit holders was generally higher for HD 325 than other Gravelly-Snowcrest HDs and most, but not all of this pressure was concentrated on the Blacktail Ridge – Clark Canyon population.

Population Estimates

We described our methods of estimating population numbers and their relative reliability earlier in Chapter 3 - Methods. Mark-recapture and sightability techniques were not used because of the difficulty of reliably detecting all marked animals in large groups of 500+, often 800+ elk. Also, initial study design did not allow for the expense of applying these methods.

In general terms, our best estimates (Table 5.3) indicated that the total post-season elk population in the Gravelly-Snowcrest Mountains population ranged from 6-10,000 elk from 1983-1984 to 1994-1995. An increasing trend was indicated through about 1993-1994 and then the population stabilized (Table 5.3). These annual estimates were generally consistent with each other when estimates of hunting loss, wounding loss, natural loss, and calf production/survival were accounted for each year.

As seems typical of most estimates and models, numbers of bulls estimated were less likely to reconcile each year. This probably occurred for two reasons. Estimated numbers of bulls were based on post-season classifications, which likely consistently underestimated the number of bulls to at least some degree. Also, it is possible based on check station and capture sex ratios, that males made up fewer than the 50% of recruited yearlings we assumed. If true, we likely over estimated numbers of yearling bulls recruited in some years and underestimated BTB surviving in most years. Those factors may have varied inconsistently among years. Because the number estimated in each sex/age category was partially based on classifications and relative to each other, numbers estimated for cows and calves also contain various degrees of error.

Table 5.3. Aerial trend counts of elk and population estimates by 3 methods for the Gravelly-Snowcrest Mountains, Montana, 1983-1984 to 1998-1999.

Year			Population Estimate			
				Age Structure Reconstruction		
	Aerial Count	Observability[a]	Mortality Rate[b]	Method 1[b]	Method 2[b]	Best est.[c]
1983-84					6,632	
1984-85	3,940					
1985-86	3,341	0.44			7,638	
1986-87	4,521	0.74			6,138	
1987-88	4,449	0.61	7,191	7,696	7,101	7,329
1988-89	4,804	0.64	7,476	7,219	7,693	7,463
1989-90	6,066	0.77	9,723	8,148	7,590	7,869
1990-91	5,124	0.56	10,790	8,883	7,697	9,123
1991-92	7,316	0.79	6,989			9,309
1992-93	7,245	0.80	15,445			9,066
1993-94	6,134	0.61	13,685			10,132
1994-95	8,161	0.89	8,455			9,147
1995-96	7,696		8,217			
1996-97	8,242					
1997-98	7,791					
1998-99	8,023					

[a] Observability = aerial trend count/best estimate.

[b] Description of methods of making population estimates is in Methods Chapter.

[c] Best estimate is average of other estimates, 1987-1988 to 1990-1991 and for years after that, it is the 1990-1991 estimate minus hunting and natural losses, plus new calf recruitment at end of year. This was carried only through 1994-1995, because it became less reliable each year.

Despite these problems, the estimates for 1987-1988 to 1994-1995 probably were relatively close to the actual numbers because they reconciled with known and estimated losses and gains to the population. Estimates for 1983-1984 to 1986-1987 and 1995-1996 to 1998-1999 were less reliable (Table 5.3). They did indicate that the population probably had fewer elk (6,000-7,000) in the early period and may have stabilized at 9,000-10,000 elk after 1993-1994.

If we assume that the best estimates for 1987-1988 to 1994-1995 were relatively accurate, we can calculate observability indexes for our trend flight counts (Table 5.3). It appeared that during normal to severe winters, when most elk were on traditional winter ranges, we counted about 80% of the elk present during our trend flight counts (Table 5.3). When elk were widely dispersed during mild winters such as in 1990-1991 and 1993-1994, we counted about 60% of the elk in the population during our trend flight counts (Table 5.3). A biologist regularly working with the population can categorize winter and elk distribution conditions at the time of the trend count flight with relative confidence. If only a general estimate of population level is sufficient for management decisions, an observability factor could be applied each year based on weather conditions and elk distribution. Application of these factors indicated that the post-season population may have ranged between 9,600 – 10,700 during 1995-1996 to 1999-2000.

Undercounts occur for several reasons. Observers do not see some groups of elk within the area surveyed. The groups missed are most commonly smaller groups. Sightability models (Samuel et al. 1987, Unsworth et al. 1990) attempt to quantify this factor. This sightability correction is more important on forested winter range counts or other areas where large portions of the elk are in small groups. Neither was the case for the majority of elk in the Gravelly-Snowcrest Mountain winter ranges (Table 5.4). On the open winter ranges with large numbers of elk only about 2.5% of elk observed were in groups of ≤ 20 (Table 5.4). That percentage was higher on the smaller, more timbered winter ranges (8.9%, Table 5.4) but overall, only 5.7% of elk observed on our flights were in groups of ≤ 20. Groups of >400 elk comprised 33.6% of elk observed and groups > 100 elk were 71.7% of elk observed.

Table 5.4. Distribution of group sizes and number of elk observed on trend flight surveys, Gravelly-Snowcrest Mountains, 1987-1988 through 1996-1997.

Group size	WCWMA and BTWMA		All other winter ranges		Total	
	No. groups(%)	No. elk (%)	No. groups(%)	No. elk(%)	No. groups(%)	No. elk(%)
≤5	35 (14.2)	113(0.4)	125 (19.9)	363(1.2)	160 (18.3)	476(0.8)
6-20	60 (24.3)	631(2.1)	200 (31.9)	2,328(7.7)	260 (29.7)	2,959(4.9)
21-50	47 (19.0)	1,481(4.9)	129 (20.5)	4,108(13.5)	176 (20.1)	5,589(9.2)
51-100	32 (13.0)	2,094(6.9)	84 (13.4)	6,053(19.9)	116 (13.3)	8,147(13.4)
101-200	30 (12.2)	3,227(10.6)	58 (9.2)	8,078(26.6)	88 (10.1)	11,305(18.6)
201-400	18 (7.3)	4,843(16.0)	27 (4.3)	7,014(23.1)	45 (5.1)	11,857(19.5)
401-600	11 (4.5)	5,282(17.4)	4 (0.6)	1,839(6.0)	15 (1.7)	7,121(11.7)
601-1,000	10 (4.1)	7,953(26.2)	1 (0.2)	642(2.1)	11 (1.3)	8,595(14.2)
≥1,001	4 (1.6)	4,701(15.5)	0	0	4 (0.5)	4,701(7.7)
Total	247	30,325	628	30,425	875	60,750

We used the correction factor for group size in the sightability model for the open winter ranges of the Northern Yellowstone elk winter range (Singer and Garton 1994) and applied it to all of our observations to obtain an average sightability. Two of the pilots used in their study were the pilots we used. That estimate provided an average sightability of 0.974, applied to an average entire annual survey. This high sightability occurred because of the large group sizes in our study area. We did not record data to correct for vegetation cover or elk activity, but that would have had little impact, perhaps lowering the average sightability to no lower than 0.90. Sightability models should be developed for each area, but we believe that the model for the Northern Yellowstone population would be relatively close to one developed for the Gravelly-Snowcrest area.

Large groups are seldom missed, but occasionally, for various reasons they are. For example, we know we missed one group of about 200 elk on the WCWMA during the 1989-1990 trend flight and a group of 319 elk on the Robb-Ledford area in 1991-1992. The effect of missing these large groups can be substantial and is not addressed by corrections in sightability models, which assume a probability of 1.0 for detection of large groups.

Another reason aerial counts do not record the "true" numbers of animals is that animals are miscounted in the groups that are observed. The literature and our anecdotal experience indicated that animals in large groups are usually undercounted. Freddy (1998, 2000) considered this factor a major explanation of underestimation error in a Colorado elk population. Cogan and Diefenbach (1998) estimated that crews counting elk from a helicopter in Pennsylvania undercounted elk that were observed by about 20 percent. Thus, there usually is at least a slight bias toward fewer animals counted than are present within groups observed.

A third reason that trend counts are underestimates of "true" population numbers is that either by design or because animals are widely distributed, not all areas with animals that are included in the population are counted. This situation occurred to at least some extent every year in the migratory populations we attempted to count. It was a major factor influencing total counts during years such as 1990-1991 and 1993-1994 (Table 5.1 and 5.3) when elk were widely distributed all winter, including some elk that remained in Idaho. The impact of this factor varieds among years, but probably was the major reason that our estimated observability was 60% in some years rather than near 80% in most years.

The average 80% observability that we estimated for most years (Table 5.3) was probably due to: (1) an average 90-95 % sightability of elk groups within the areas we flew and (2) reductions totaling 10-15 % from undercounting elk within large groups and not covering all areas where elk were located, even during severe winters. During 1990-1991 and 1993-1994, a substantial portion of the population apparently was distributed in areas not covered by our trend flights, resulting in an overall 60% observability.

Density

We calculated density estimates based on our population estimates and information on population and herd range distribution (Chapter 9). These estimates are subject to error, but do allow for comparison with other areas, at least within broad ranges. We estimate that preseason elk numbers for the Gravelly-Snowcrest complex averaged about 13,300 elk recently and the elk used about 9,765 km^2 (3,770 mi^2) of yearlong range. This provided an estimate of 1.36 elk/ km^2 (3.5 elk/ mi^2) of yearlong range. If we subtract areas of non-use within the polygon of population distribution, elk occupied about 6,915 km^2 (2,670 mi^2). This indicated a density on yearlong range of 1.92 elk/ km^2 (5.0 elk/ mi^2), or 1.53 adult elk/ km^2 (4.0 adult elk/ mi^2). We did not calculate yearlong herd range densities because of overlap of herd ranges.

Post-season winter range densities at recent highs were approximately 26 elk/ km^2 (66 elk/ mi^2) and 62 elk/ km^2 (160 elk/mi^2) for the Blacktail and Wall Creek winter ranges, respectively.

CHAPTER 6

SEX AND AGE STRUCTURE

Sex Ratio of Calves

We captured only small samples of newborn calves annually during 1984-1988. The combined sample was 40 males and 32 females, or 125 males: 100 females. Sex ratio for a sample of 202 newborn calves captured in the Gravelly-Snowcrest Mountains during the late 1950s and early 1960s was 113 males: 100 females (Rouse 1957,1959, 1960,1961, Peek 1967). Although both samples were typical of other data indicating a slight early preponderance of males, their accuracy may be questionable because of small annual samples. Large samples (1,082 calves) collected during 1938-1960 in the Gallatin drainage (Peek et al. 1967) and from the Sun River area (472 calves) during 1937-1960 (Picton 1961) indicated 99 and 102 males:100 females, respectively. Lemke (2000, 2001) reported 103 males:100 females for the *in utero* sex ratio of 543 fetuses in the Northern Yellowstone elk population in 2000 and 2001.

If the fetal sex ratios observed in the Gravelly-Snowcrest Mountains were accurate, the hypothesis of adaptive sex ratios (Trivers and Willard 1973, Kohlmann 1999) would postulate that adult female elk were in above average physical condition during the period, given the preponderance of male fetuses.

Sex ratio of hunter-killed calves (Table 6.1) indicated considerable mortality of male calves relative to females occurred in the first 6 months of life. The difference in ratios between calves at check stations (70.9 males:100 females) and those of hunter reported and turned in jaws (58.3 males: 100 females) was not significant ($\chi^2_1 = 2.08$, $P = 0.15$). However our experience indicated that hunters commonly report male calves as females, either because of the lack of antler buds or because they prefer not to have killed a "potential antlered bull". Some of these examples were discovered at check stations, but others were likely unrecorded because of condition of the carcass or because check station attendants did not question hunter reports. Therefore, we believe that the calf sex ratio reported at check stations during autumn is a minimum for males (Table 6.1).

Hunters probably prefer to shoot larger bodied antlerless elk to obtain a greater quantity of meat. Calves were shot at about 60% of the rate of adult cows, based on their proportion in the population (Table 6.1). Hunters turning in mandible tags reported calves significantly less in proportion to cows than recorded at check stations (Table 6.1, $\chi^2_1 = 25.9$, $P < 0.001$). This reluctance to report shooting calves was further documented in reporting on the Statewide Hunter Questionnaire. During 1984-1994, hunters reported shooting 14.5 calves:100 cows compared to a mean of 29.4 calves:100 cows observed at check stations during the same period. Thus, calves were reported at about half (0.493) the rate on the SWHQ as observed at check stations. Calves may be reported as "yearling" cows to SWHQ interviewers, inflating SWHQ estimates of cows harvested and underestimating harvest of calves. In AB areas, male calves also may be reported as "spike" bulls.

Table 6.1. Sex ratio of calves and calf:100 cow ratio for hunter-killed elk, Gravelly-Snowcrest Mountains, 1984-1996.

	Check Stations					Voluntary Jaw Returns				
Year	Female Calves	Male Calves	M:100F	Cows	Calves: 100 Cows	Female Calves	Male Calves	M:100F	Cows	Calves: 100 Cows
1984	13	11	84.6	96	25.0					
1985	20	10	50.0	108	27.8	21	12	57.1	133	24.8
1986	19	11	57.9	97	30.9	18	7	38.9	128	19.5
1987	26	16	61.5	145	29.0	18	11	61.1	138	21.0
1988	26	14	53.9	175	22.9	23	8	34.8	155	20.0
1989	31	27	87.1	144	40.3	17	14	82.4	157	19.8
1990	21	9	42.9	119	25.2	13	6	46.2	121	15.7
1991	33	26	78.8	174	33.9	23	16	69.6	171	22.8
1992	29	24	82.8	180	29.4	20	11	55.0	183	16.9
1993	23	17	73.9	129	31.0	16	11	68.8	137	19.7
1994	29	29	100.0	223	26.0	40	20	50.0	247	24.3
1995	13	12	92.3	117	21.4	15	11	73.3	174	14.9
1996	40	23	57.5	201	31.3	23	17	73.9	205	19.5
Total	**323**	**229**	**70.9**	**1908**	**28.9**	**247**	**144**	**58.3**	**1949**	**20.1**

We observed a sex ratio of 76 males:100 females among 345 calves captured during winters 1984-92 by use of a helicopter and drive net. This sex ratio for 9- to 10-month-old calves is similar to, but slightly higher than the ratio observed at check stations. Sex ratios of hunter-killed calves in other areas of Montana were similar, ranging from 67 to 99 males:100 females with an average of 78 males:100 females (MFWP, unpubl.). Given the problems of obtaining unbiased samples, we estimate that at the end of the first year of life, sex ratio for elk in the Gravelly-Snowcrest Mountains was 70-80 males:100 females. This indicated mortality 25% higher for males than females during the first year of life at a 100:100 initial sex ratio and 35% higher at an initial sex ratio of 116 males:100 females. Lemke (2000, 2001) also reported a probable higher mortality of male than female calves for the Northern Yellowstone elk population. He recorded 51 males:100 females for hunter-killed calves compared to 103 males:100 females for a fetal sex ratio.

Sex and Age Classifications for the Population

Pre-season classifications during June and July (especially aerial classifications) may sometimes misclassify some small spike-antlered yearling males as cows. For pre-season classifications, we report calves:100 cows + spikes in addition to the traditional calves:100 cows ratio. These surveys concentrated on determining calf:100 cow ratios and we likely underestimated bull:100 cow ratios. Classifications during June may underestimate numbers of calves because some may remain hidden.

During 6 pre-season surveys, 1961-1977, averages of 59.9 calves:100 cows and 19.9 bulls:100 cows were observed (Table 6.2). During 1980-1982, a period of concern about low calf:100 cow ratios, an average of 38.7 calves:100 cows was observed (Table 6.2). This indicated a 35% decline in calf survival to about 1-2 months of age from earlier

Table 6.2. Pre-season sex-age classifications of elk, Gravelly-Snowcrest Mountains, 1961-1996.

Area	Date	Total Elk	Calves/100 Cows	Calves/100 Cows+Spikes	Bulls/100 Cows	BTB[a]/100 Cows	% Bulls	% BTB
General, Helicopter	09-61	811	57.8		40.9		20.6	
Gravellys, Helicopter	07-27-70	937	56.7	49.0	17.5	1.9	10.0	1.1
HD 325, Fixed-wing	07-28-72	195	50.8	46.6	9.0	0	5.6	0
Upper Ruby, ground	07-25-73	134	67.6	61.0	10.8	0	6.0	0
Upper Ruby, ground	07-08-74	47	67.9					
HD 325, Fixed-wing	07-08-77	135	58.7	55.7	21.3	16.0	11.9	8.9
Upper Ruby, ground	06-80	261	37.4					
Upper Ruby, ground	06-81	409	38.6					
HD 325, Fixed-wing	07-18-81	163	27.3					
Long Cr., ground	06-22-82	195	41.6	34.6	31.0	10.6	18.0	6.2
Lazyman-Cherry Cr.	07-82	50	50.0	44.1				

[a] BTB = Brow-tined bulls

Table 6.2.(cont.)

Area	Date	Total Elk	Calves/100 Cows	Calves/100 Cows+Spikes	Bulls/100 Cows	BTB/100 Cows	% Bulls	% BTB
Gravellys, ground	07-84	1023	45.6	44.3	6.3	3.2	6.0	3.0
Upper Ruby, ground	06-85	408	50.7	45.6	14.3	3.3	5.4	1.2
General, ground	07-85	99	50.0	41.5				
General, Fixed-wing	07-85	824	53.8	51.0	9.7	4.4	6.0	2.7
Long Cr., ground	06-25-86	163	57.3	49.0	25.8	9.0	14.1	4.9
HD 325, Fixed-wing	07-15-86	210		40.0				
General, helicopter	07-86	1050	59.9	49.6	24.0	3.3	13.1	1.8
General, helicopter	07-87	1123	47.6	43.7	10.6	1.7	6.7	1.1
General, helicopter	07-88	671	52.2	46.3	14.7	1.7	8.8	1.0
General, helicopter	07-89	1570	51.7	47.6	11.0	2.3	6.8	1.4
General, helicopter	07-90	1674	45.1	43.1	7.1	2.5	4.7	1.7
General, helicopter	08-95	480	26.2	21.9	32.8	13.6	20.6	8.5
General, helicopter	07-96	1520	45.6	42.8	11.1	4.5	7.1	2.9

averages. Excluding 1995 when calf survival was unusually low, we observed an average of 50.3 calves:100 cows during 1984-1996. Thus, during the mid-1980s through the mid-1990s, pre-season calf:100 cow ratios recovered to within about 16% of the level observed prior to 1980. We observed an average of 15.2 bulls:100 cows during summers 1984-1996, which although probably lower than the actual average, compares with the 19.9 bulls:100 cows observed during 1961-1977. All years for which there were data except 1980, 1981, and 1995 had pre-season calf:100 cow ratios above 43:100.

We used aerial classifications to determine proportion of bulls in the population during post-season surveys (Table 6.3). Aerial surveys were more likely to include small groups of bulls or single bulls on the fringes of winter range than were surveys from the ground. Fixed-wing aerial classifications, however, were more likely to underestimate occurrence of spike bulls. The earliest classifications (Table 6.3) did not indicate proportions of bulls substantially greater than more recent classifications. Perhaps bulls were always heavily harvested in this area. During the late 1960s through the 1970s total bulls averaged 7.7% of the population, declining to 3.1% during 1980 and 1981. During 1960-1980, when any antlered bull was legal to harvest, brow-tined bulls comprised an average 28.6% of bulls classified post-season.

Total bulls averaged 7.3% of the population and brow-tined bulls were 10.7% of total bulls in post-season classifications during 1982-1990. Total bulls were a similar, but slightly smaller proportion of the population during BAB regulations compared to AB regulations ($\chi^2_1 = 4.09$, $P = 0.043$). The proportion of bulls that were BTB declined during the period of BAB regulations ($\chi^2_1 = 118.6$, $P < 0.001$). The BAB regulation may have put more hunting pressure on older bulls, resulting in a heavier harvest rate for this age category than occurred with the AB regulation. Also, more spikes survived, decreasing the proportion of BTB. Bulls averaged 10.3% of the population and BTB were 18.4% of all bulls in post-season classifications during 1991-2000. Total bulls were a greater proportion of the population in post-season classifications during 1991-2000 than 1968-1979 ($\chi^2_1 = 120.8$, $P < 0.001$), and 1982-90 ($\chi^2_1 = 217.5$, $P < 0.001$). Brow-tined bulls were a greater proportion of the bull population in 1991-2000 compared to 1982-1990 ($\chi^2_1 = 79.1$, $P < 0.001$), but were a smaller proportion compared to 1968-1979 ($\chi^2_1 = 31.6$, $P < 0.001$). Although the differences for total bulls were slight, these data indicated that the proportion of total bulls in the population increased in the following order of regulation type: BAB, AB, and BTB. The percentage of BTB in the post-season bull population increased in the following order of regulation type: BAB, BTB, and AB. It appeared that bulls ≥ 3 years old increased in the post-season population after implementation of BTB regulations (1981-1983), but data were recorded during only 2 years of BAB regulations (Table 6.3).

Table 6.3. Aerial classifications of elk in the Gravelly-Snowcrest Mountains during winter-spring, 1955-2000.

Year	Total Elk Classified	Total Bulls (%)[a]	Yearling Bulls (%)[a]	BTB[b] (%)[a]	BTB as % of Bulls (% ≥3 years)[c]
1955	1089	174 (16.0)	87 (8.0)	87 (8.0)	50.0
1962	239	14 (5.9)			
1963	414	45 (10.9)			
1968	1575	84 (5.3)	66 (4.2)	18 (1.1)	21.4
1969	1556	68 (4.4)	51 (3.3)	17 (1.1)	25.0
1972	810	70 (8.6)	50 (6.2)	20 (2.5)	28.6
1973	2074	126 (6.1)	81 (3.9)	45 (2.2)	37.7
1974	589	56 (9.5)	26 (4.4)	30 (5.1)	53.6
1975	305	33 (10.8)	19 (6.2)	14 (4.6)	42.4
1976	641	48 (7.5)			
1977-79	509	48 (9.4)	46 (9.0)	2 (0.4)	4.2
1980	1834	70 (3.8)	52 (2.8)	18 (1.0)	25.7
1981	1152	26 (2.3)	21 (1.8)	5 (0.4)	19.2
1982	2523	214 (8.5)			
1983	4128	190 (4.6)	168 (4.1)	22 (0.5)	11.6
1984	5435	362 (6.7)	336 (6.2)	26 (0.5)	7.2
1985	1227	101 (8.2)	89 (7.3)	12 (1.0)	11.9
1987	1523	88 (5.8)	78 (5.1)	10 (0.7)	11.4
1988	2287	203 (8.9)	173 (7.6)	30 (1.3)	14.8
1989	2736	166 (6.1)	153 (5.6)	13 (0.5)	7.8 (0.5)
1990	4600	457 (9.9)	412 (9.0)	45 (1.0)	9.9 (1.1)
1991	4270	357 (8.4)	287 (6.7)	70 (1.6)	19.6 (3.9)
1992	6894	628 (9.1)	597 (8.7)	31 (0.4)	4.9 (0.7)
1993	7245	620 (8.6)	557 (7.7)	63 (0.9)	10.2 (3.5)
1994	5827	607 (10.4)	468 (8.0)	139 (2.4)	22.9 (2.7)
1995	8161	837 (10.3)	715 (8.8)	122 (1.5)	14.6 (4.4)
1996	7945	725 (9.1)	567 (7.1)	158 (2.0)	21.8 (4.6)
1997	8233	628 (7.6)	510 (6.2)	118 (1.4)	18.8 (2.4)
1998	8041	1000 (12.4)	799 (9.9)	201 (2.5)	20.1 (3.2)
1999[d]	8232	986(12.0)	796(9.7)	190(2.3)	19.3 (3.5)
2000[d]	8524	1319(15.5)	905(10.6)	414(4.9)	31.4 (8.2)

[a] % = percent of total elk population.

[b] BTB = Brow-tined bulls (≥2 years old).

[c] Number in parenthesis = percent of BTB that were ≥3 years old.

[d] Classifications by Bob Brannon, MFWP area biologist.

Data in Table 6.3 represent the entire Gravelly-Snowcrest population. However, these data were not collected at equal intensities for all areas each year. Thus, this data represented a variety of sub-populations that were inconsistently sampled each year. Data were collected more consistently on the Wall Creek Wildlife Management Area (WCWMA) and the Blacktail Wildlife Management Area (BTWMA) each year (Tables 6.4 and 6.5). These data represented a combination of aerial surveys and classifications made from the ground. With some exceptions, the proportions of bulls and total numbers were from aerial classifications and the calf:100 cow ratios were from classifications made from the ground. The highest total numbers and bull numbers were used from either source and the difference in these 2 numbers was partitioned into cows and calves based on classifications made from the ground.

Long-term average post-season calf:100 cow ratios compared for the same years at the WCWMA (42.0:100, Table 6.4) and the BTWMA (41.8:100, Table 6.5) were not different ($t_{36} = 0.055$, $P = 0.957$). Also, total bull:100 cow ratios were not different between the WCWMA (15.2:100) and the BTWMA (15.3:100) ($t_{36} = -0.088$, $P = 0.930$). Post-season BTB:100 cow ratios were higher on the WCWMA (4.00:100) than on the BTWMA (1.57:100) ($t_{36} = 3.28$, $P = 0.002$). Variances were also different ($F = 4.93$, $P = 0.002$), indicating that ratios on the BTWMA were consistently low, but those on the WCWMA were almost 3 times the average in some years. Similarly, BTB as a percent of total bulls was consistently higher on the WCWMA (24.2%) than the BTWMA (10.1%) ($t_{44} = 4.72$, $P < 0.001$).

Total bull:100 cow ratios were not significantly different on either the BTWMA (14.5:100 and 17.6:100, $t_{14} = 1.069$, $P = 0.303$) or WCWMA (16.2:100 and 17.2:100, $t_{14} = 0.375$, $P = 0.713$) between periods when harvest regulations were BAB and BTB. No differences were apparent between periods of BAB and BTB regulations on the BTWMA for either BTB:100 cow ratios (1.3:100 and 2.0:100, $t_{14} = 0.460$, $P = 0.652$) or BTB as a % of total bulls (8.6% and 10.5%, $t_{17} = 0.691$, $P = 0.499$). Although not significantly different, all bull ratios were consistently higher for BTB than BAB regulations. On the WCWMA, however, BTB:100 cow ratios were twice as high ($t_{14} = 2.48$, $P = 0.027$) during years with BTB regulations (5.7:100) than years with BAB regulations (2.5:100). The percent of total bulls in post-season classifications that was BTB was significantly higher ($t_{17} = 4.37$, $P = 0.0004$) during years of BTB regulations (31.1%) than years of BAB regulations (14.3%) on the WCWMA. Hunting regulation type was the same on areas used by elk wintering on the WCWMA and BTWMA. Therefore, increased survival of bulls wintering on the WCWMA may have been related to a combination of greater hiding cover, fewer roads, and more use early in the hunting season of areas in YNP and in Idaho by these elk.

When possible, we classified yearling bulls as spikes (1 × 1 points) or branch-antlered (any visible branch). Although we did not use classifications made from very long distances for this purpose, the number of branch-antlered yearlings recorded should be considered minimal. Of radiocollared yearling bulls for which we could determine antler branching during 1991-1994, 11 (18.0%) of 61 were branch-antlered. Post-season

Table 6.4. Post-season (winter-spring) sex-age classifications of elk on the Wall Creek Wildlife Management Area, 1968-2000.[a]

Year	Total Elk	Total Bulls (%)	Yearling Bulls (%)	BTB[b] (%)	Cows (%)	Calves (%)	Calves/ 100 Cows	Bulls/100 Cows	BTB/100 Cows	BTB as % Of Bulls
1968	455	28 (6.2)	24 (5.3)	4 (0.9)	254 (55.8)	173 (38.0)	68.1	11.0	1.6	14.3
1969	539	22 (4.1)	19 (3.5)	3 (0.6)						13.6
1973	662	54 (8.2)	35 (5.3)	19 (2.9)						35.2
1976	440	35 (8.0)								
1980	535	50 (9.4)	34 (6.4)	16 (3.0)						32.0
1981	1005	26 (2.6)	19 (1.9)	7 (0.7)	804 (80.0)	175 (17.4)	21.8	3.2	0.9	26.9
1982	725	39 (5.4)	31 (4.3)	8 (1.1)	503 (69.4)	183 (25.2)	36.4	7.8	1.6	20.5
1983	1072	57 (5.3)	48 (4.5)	9 (0.8)	743 (69.3)	272 (25.4)	36.6	7.7	1.2	15.8
1984	885	84 (9.5)	75 (8.5)	9 (1.0)	574 (64.9)	227 (25.7)	39.6	14.6	1.6	10.7
1985	950	67 (7.1)	56 (5.9)	11 (1.2)						16.4
1986	619	62 (10.0)	52 (8.4)	10 (1.6)	397 (64.1)	160 (25.9)	40.3	15.6	2.5	16.1
1987	900	79 (8.8)	65 (7.2)	14 (1.6)	537 (59.6)	284 (31.6)	52.9	14.7	2.6	17.7
1988	1182	141 (11.9)	108 (9.1)	33 (2.8)	654 (55.3)	387 (32.7)	59.2	21.6	5.1	23.4
1989	1401	67 (4.8)	64 (4.6)	3 (0.2)	923 (65.9)	411 (29.3)	44.5	7.3	0.3	4.5
1990	880	120 (13.6)	105 (11.9)	15 (1.7)	511 (58.1)	249 (28.3)	48.7	23.5	2.9	12.5
1991	1249	129 (10.3)	91 (7.3)	38 (3.0)	753 (60.3)	367 (29.4)	48.7	17.1	5.1	29.5
1992	1360	90 (6.6)	73 (5.4)	17 (1.3)	814 (59.9)	456 (33.5)	56.0	11.1	2.1	18.9
1993	1379	153 (11.1)	133 (9.6)	20 (1.5)	857 (62.2)	369 (26.8)	43.1	17.9	2.3	13.1
1994	1591	172 (10.8)	115 (7.2)	57 (3.6)	946 (59.5)	473 (29.7)	50.0	18.2	6.0	33.1
1995	2002	174 (8.7)	124 (6.2)	50 (2.5)	1223 (61.1)	605 (30.2)	49.5[c]	10.1	4.1	28.7
1996	1594	199 (12.5)	130 (8.2)	69 (4.3)	1137 (71.3)	257 (16.1)	22.6	17.5	6.1	34.7
1997	1965	182 (9.3)	137 (7.0)	45 (2.3)	1259 (64.1)	524 (26.7)	41.6	14.5	3.6	24.7
1998	1637	234 (14.3)	142 (8.7)	92 (5.6)	1039 (63.5)	364 (22.2)	35.0	22.5	8.9	39.3
1999[d]	1853	208 (11.2)	114 (6.2)	94 (5.1)	1182 (63.8)	463 (25.0)	39.2	17.6	8.0	45.2
2000[d]	2344	378 (16.1)	214 (9.1)	164 (7.0)	1481 (63.2)	485 (20.7)	32.8	25.5	11.1	43.4

[a] Numbers do not exactly match either aerial or ground classifications in some years. The highest total and bull numbers observed were used. The difference between those two numbers was partitioned into cows and calves using ground classification data.

[b] BTB = Brow-tined bulls.

[c] Mortality may have occurred after this classification (January), a sample classification on 27 April indicated 30.2 calves/100 cows.

[d] Classifications by Bob Brannon, MFWP area biologist.

Table 6.5. Post-season (winter-spring) sex-age classifications of elk on the Blacktail Wildlife Management Area, 1968-2000.[a]

Year	Total Elk	Total Bulls (%)	Yearling Bulls (%)	BTB[b] (%)	Cows (%)	Calves (%)	Calves/ 100 Cows	Bulls/100 Cows	BTB/100 Cows	BTB as % of Bulls
1968	425	6 (1.4)	6 (1.4)	0						0
1972	467	43 (9.2)	29 (6.2)	14 (3.0)	274 (58.7)	150 (32.1)	54.7	15.7	3.0	32.6
1973	591	48 (8.1)	28 (4.7)	20 (3.4)						41.7
1980	775	11 (1.4)	10 (1.3)	1 (0.1)	626 (80.8)	138 (17.8)	22.0	1.8	0.2	9.1
1981	484	7 (1.5)	7 (1.5)	0	350 (72.3)	127 (26.2)	36.3	2.0	0	0
1982	905	91 (10.1)	89 (9.8)	2 (0.2)	581 (64.2)	233 (25.8)	40.1	15.7	0.3	2.2
1983	1079	56 (5.2)	55 (5.1)	1 (0.1)	737 (68.3)	286 (26.5)	38.8	7.6	0.1	1.8
1984	1376	97 (7.1)	95 (6.9)	2 (0.2)	943 (68.5)	336 (24.4)	35.6	10.3	0.2	2.1
1985	788	73 (9.3)	65 (8.3)	8 (1.0)	436 (55.3)	279 (35.4)	64.0	16.7	1.8	11.0
1986	663	89 (13.4)	75 (11.3)	14 (2.1)	422 (63.7)	152 (22.9)	36.0	21.1	3.3	15.7
1987	2160	235 (10.9)	214 (9.9)	21 (1.0)	1245 (57.6)	680 (31.5)	54.6	18.9	1.7	8.9
1988	1712	150 (8.8)	137 (8.0)	13 (0.8)	1094 (63.9)	468 (27.3)	42.8	13.7	1.2	8.7
1989	1726	128 (7.4)	109 (6.3)	19 (1.1)	1096 (63.5)	502 (29.1)	45.8	11.7	1.7	14.8
1990	2022	180 (8.9)	158 (7.8)	22 (1.1)	1232 (60.9)	610 (30.2)	49.5	14.6	1.8	12.2
1991	1028	100 (9.7)	88 (8.6)	12 (1.2)	589 (57.3)	339 (33.0)	57.6	17.0	2.0	12.0
1992	1662	117 (7.0)	115 (6.9)	2 (0.1)	1020 (61.4)	525 (31.6)	51.5	11.5	0.2	1.7
1993	1801	150 (8.3)	149 (8.3)	1 (0.1)	1119 (62.1)	532 (29.5)	47.5	13.4	0.1	0.7
1994	1815	156 (8.6)	129 (7.1)	27 (1.5)	1139 (62.8)	520 (28.7)	45.7	13.7	2.4	17.3
1995	1621	180 (11.1)	163 (10.1)	17 (1.1)	952 (58.7)	489 (30.2)	51.4[c]	18.9	1.8	9.4
1996	1845	218 (11.8)	185 (10.0)	30 (1.6)	1360 (73.7)	267 (14.5)	19.6	16.0	2.2	13.8
1997	1841	174 (9.5)	154 (8.4)	20 (1.1)	1175 (63.9)	492 (26.7)	41.9	14.8	1.7	11.5
1998[d]	2122	277 (13.1)	250 (11.8)	27 (1.3)	1373 (64.7)	472 (22.2)	34.4	20.2	2.0	9.8
1999[d]	1718	238 (13.9)	220 (12.8)	18 (1.1)	992 (57.7)	488 (28.4)	49.2	24.0	1.8	7.6
2000[d]	2124	388 (18.3)	307 (14.5)	81 (3.8)	1488 (70.0)	248 (11.7)	16.7	26.1	5.4	20.9

[a] Numbers do not exactly match either aerial or ground classifications in some years. The highest total and bull numbers observed were used. The difference between those two numbers was partitioned into cows and calves using ground classification data.

[b] BTB = Brow-tined bulls.

[c] Mortality may have occurred after this classification (February), a sample classification on 26 April indicated 16.3 calves/100 cows.

[d] Classifications by Bob Brannon, MFWP area biologist.

classifications for the Gravelly-Snowcrest population (Table 6.6) indicated that the percent of branch-antlered yearling bulls was higher ($\chi^2_1 = 11.39$, $P < 0.001$) during years of BTB regulations than during years of BAB regulations. Both percentages (Table 6.6) were lower than the 18% observed for radiocollared yearling bulls, possibly indicating disproportionate illegal mortality of branch-antlered yearling bulls compared to spikes.

Table 6.6. Branching rate of yearling bulls classified post-season, 1981-1982 through 1996-1997, Gravelly-Snowcrest Mountains.

Year	Total Classified	1 x 1 Antlers	Branched Antlers[a]	% Branched
1981-82[b]	89	81	8	9.0
1982-83	55	53	2	3.6
1985-86	75	70	5	6.7
1986-87	65	59	6	9.2
1987-88	71	61	10	14.1
1988-89	175	169	6	3.4
1989-90	39	37	2	5.1
BAB[c] Total	**569**	**530**	**39**	**6.9 (7.3)[d]**
1990-91	254	221	33	8.7
1991-92	730	660	70	9.6
1992-93	772	669	103	13.3
1993-94	63	51	12	19.1
1994-95	423	371	52	12.3
1995-96	133	126	7	5.3
1996-97	221	194	27	12.2
BTB[e] Total	**2596**	**2292**	**304**	**11.7 (11.5)[d]**

[a] Antler with any visible branch, some are missed because many classifications take place from a distance.

[b] Year = hunting season-winter classification.

[c] BAB = Branch-antlered Bull regulation in effect.

[d] % of total raw observations (% calculated with each year's % as the data points).

[e] BTB = Brow-tined Bull regulation in effect.

Age Structure of Hunter-Killed Adult Elk

During 1984-1988, hunter-killed elk were aged only by eruption-wear criteria of mandibles. Ages were assigned to individual year classes through 4 years of age and older elk were assigned to grouped age classes 5-6, 7-8, and ≥9 years. Elk were aged by both incisor cementum annuli and eruption-wear criteria during 1989-1996 and assigned to individual year classes (Hamlin et al. 2000). To facilitate comparisons among all years, combined year classes were used for some analyses.

Ages assigned by eruption-wear generally indicated a typical pyramidal age structure, but there were important deviations. Age-class 4 comprised a greater percentage of the population than age-class 3 in 9 of 13 years and was nearly equal in the others (Table 6.7). Although severe calf mortality in a year could temporarily result in age-class 4 being larger than age-class 3 as the weak year class reached 3 years of age, this could not happen consistently over a 13-year period in a stable or growing population. Thus, the consistency of large 4-year-old age classes indicated consistent errors in age assignments made by eruption-wear criteria.

Hamlin et al. (2000) reported that the cementum annuli technique was accurate in 97.3% of age assignments of 111 known-age Montana elk. They also reported that ages assigned by eruption-wear were accurate for 58% of 3 year olds and 56% of 4 year olds and were only accurate to year class 29% or less of the time for elk ≥ 5 years old. Because the same group of people generally aged the elk by eruption-wear criteria each year, we believed that data presented by Hamlin et al. (2000) could be used to proportionally correct ages assigned by eruption-wear to represent the "true" ages.

Ages of hunter-killed female elk based on incisor cementum annuli and corrected eruption-wear assigned ages (Table 6.8) were substantially different than ages assigned by eruption-wear criteria only (Table 6.7). In general, the percent assigned to age classes 3 and ≥ 9 years increased and the percent assigned to age classes 4 and 5-6 years old decreased when aged by incisor cementum annuli. Roybal (1998) reported similar findings. These data indicated a relatively stable age structure, but also indicated that survival for the calf cohorts of 1983, 1984, 1992, 1993, and 1995 may have been below average. Above average survival for the 1994 cohort (1995 1 year olds, Tables 6.7 and 6.8) did not reconcile with classification and mortality data. Because above average survival was also apparent for the 1994 cohort as 2 year olds in 1996 (Tables 6.7 and 6.8) it was most likely that 1995 classification data were in error and mortality data were not representative of the population.

Ages based on incisors and/or corrected eruption-wear ages and also corrected for mortality by age from cohort life tables (Table 6.9, also see Reproduction and Mortality Chapter) indicated an increase in proportions of 1- and 2-year-old females and decrease in older age classes compared to uncorrected data (Tables 6.7 and 6.8). This corrected age structure represented the pre-season population rather than the harvest age structure. These corrected data may be "overcorrections" because they indicated calf:100 cow ratios as high as 70+:100 in some years. However, if as reported earlier, more female than male calves are recruited, the age structure presented in Table 6.9 may be relatively accurate. All estimates of female age structure (Tables 6.7, 6.8, and 6.9) were likely inaccurate to some degree.

We present full age structure by year class (Table 6.10) for years when incisors were collected. These data indicated a typical pyramidal age structure, which we display in smoothed form as an exponential decay model (Fig. 6.1). The fact that 1-year-olds comprised only a slightly higher percentage of the population than 2-year-olds in these uncorrected data probably reflects hunter selection against yearlings (see Reproduction and Mortality Chapter). An average 80.3% of adult females harvested was ≤ 6 years of age and an average 54.7% was ≤ 3 years of age. Average age of adult females during 1989-1996 was 4.29 years, which was younger than the 6.80 and 6.77 years reported for the Northern Yellowstone elk population in 2000 and 2001, respectively (Lemke 2000, 2001). It was also younger than the average 5.42 years reported for the Elkhorn

Mountains during 1983-1991 (DeSimone and Vore 1992). The oldest age we recorded for a female was 21 ½ years old.

Table 6.7. Ages of hunter-killed adult female elk assigned by eruption-wear criteria, Gravelly-Snowcrest Mountains, 1984-1996.

	Age[a]							
Year	1	2	3	4	5-6	7-8	≥9	Total
1984	10(15.2)[b]	7(10.6)	2(3.0)	20(30.3)	14(21.2)	7(10.6)	6(9.1)	66
1985	29(15.3)	29(15.3)	15(7.9)	30(15.8)	53(27.9)	21(11.1)	13(6.8)	190
1986	43(20.3)	24(11.3)	26(12.3)	35(16.5)	49(23.1)	19(9.0)	16(7.6)	212
1987	56(22.1)	37(14.6)	40(15.8)	36(14.2)	46(18.2)	20(7.9)	18(7.1)	253
1988	69(22.7)	52(17.1)	49(16.1)	39(12.8)	58(19.1)	17(5.6)	20(6.6)	304
1989	60(21.2)	44(15.6)	33(11.7)	50(17.7)	57(20.1)	20(7.1)	19(6.7)	283
1990	50(21.4)	49(20.9)	32(13.7)	22(9.4)	47(20.1)	18(7.7)	16(6.8)	234
1991	61(20.1)	56(18.5)	41(13.5)	43(14.2)	43(14.2)	22(7.3)	37(12.2)	303
1992	72(21.4)	79(23.4)	33(9.8)	39(11.6)	61(18.1)	32(9.5)	22(6.5)	337
1993	41(16.7)	35(14.3)	20(8.2)	37(15.1)	53(21.6)	34(13.9)	25(10.2)	245
1994	71(17.2)	85(20.6)	48(11.7)	52(12.6)	81(19.7)	46(11.2)	29(7.0)	412
1995	69(25.9)	41(15.4)	40(15.0)	47(17.7)	43(16.2)	10(3.8)	16(6.0)	266
1996	54(15.4)	72(20.6)	70(20.0)	55(15.7)	48(13.7)	23(6.6)	28(8.0)	350

[a] Ages for adults ≥1.5 years. Age 1 = 1 year, 6 months old (age during hunting season).

[b] Number (%).

Table 6.8. Ages of hunter-killed female elk based on incisor cementum annuli and/or corrected[a] ages for those aged by eruption-wear, Gravelly-Snowcrest Mountains, 1984-1996.

	Age[b]							
Year	1	2	3	4	5-6	7-8	≥9	Total
1984	10(15.2)[c]	7(10.6)	9.2(13.9)	11.2(17.0)	13.1(19.9)	6.1(9.2)	9.4(14.2)	66
1985	29(15.3)	29(15.3)	26.3(13.8)	25.2(13.3)	36.8(19.4)	19.3(10.2)	24.4(12.8)	190
1986	43(20.3)	24(11.3)	36.4(17.2)	27.8(13.1)	36.4(17.2)	18.6(8.8)	25.9(12.2)	212
1987	56(22.1)	37(14.6)	47.7(18.9)	29.5(11.7)	36.4(14.4)	18.5(7.3)	27.9(11.0)	253
1988	69(22.7)	52(17.1)	56.9(18.7)	34.1(11.2)	41.8(13.8)	21.1(6.9)	29.1(9.6)	304
1989	60(21.5)	47(16.9)	42(15.1)	25(9.0)	41(14.7)	30(10.8)	34(12.2)	279
1990	50(21.9)	50(21.9)	31(13.6)	23(10.1)	40(17.5)	14(6.1)	20(8.8)	228
1991	61(20.0)	56(18.4)	36(11.8)	35(11.5)	36(11.8)	29(9.5)	52(17.1)	305
1992	73(21.7)	79(23.4)	48(14.2)	36(10.7)	41(12.2)	27(8.0)	33(9.8)	337
1993	41(16.3)	43(17.1)	35(13.9)	29(11.6)	51(20.3)	20(8.0)	32(12.8)	251
1994	71(17.4)	95(23.3)	62(15.2)	39(9.6)	64(15.7)	32(7.8)	45(11.0)	408
1995	69(25.8)	43(16.1)	42(15.7)	43(16.1)	27(10.1)	21(7.9)	22(8.2)	267
1996	56(15.6)	74(20.6)	73(20.3)	43(11.9)	42(11.7)	23(6.4)	49(13.6)	360

[a] Corrected based on Hamlin et al. (2000).

[b] Ages for adults ≥1.5 years. Age 1 = 1 year, 6 months old (age during hunting season).

[c] Corrected number (corrected percent).

Table 6.9. Ages of hunter-killed female elk based on incisors and/or corrected[a] eruption–wear ages and also corrected for differential mortality by age from cohort life table analysis[b], Gravelly-Snowcrest Mountains, 1984-1996.

	Age							
Year	1	2	3	4	5-6	7-8	≥9	Total
1984	12.1(18.3)[c]	7.5(11.4)	8.7(13.2)	10.6(16.1)	12.4(18.8)	5.8(8.8)	8.9(13.5)	66
1985	34.9(18.4)	30.9(16.3)	24.8(13.1)	23.7(12.5)	34.7(18.3)	18.2(9.6)	23.0(12.1)	190
1986	51.2(24.2)	25.4(12.0)	34.0(16.0)	26.0(12.3)	34.0(16.0)	17.3(8.2)	24.1(11.4)	212
1987	66.1(26.1)	38.7(15.3)	44.2(17.5)	27.3(10.8)	33.7(13.3)	17.1(6.8)	25.9(10.2)	253
1988	81.1(26.7)	54.2(17.8)	52.4(17.2)	31.4(10.3)	38.5(12.7)	19.5(6.4)	26.8(8.8)	304
1989	70.8(25.4)	49.2(17.6)	38.8(13.9)	23.1(8.3)	37.9(13.6)	27.7(9.9)	31.5(11.3)	279
1990	58.6(25.7)	52.0(22.8)	28.5(12.5)	21.1(9.3)	36.7(16.1)	12.9(5.7)	18.4(8.1)	228
1991	72.1(23.6)	58.7(19.3)	33.3(10.9)	32.4(10.6)	33.3(10.9)	26.9(8.8)	48.2(15.8)	305
1992	85.4(25.3)	82.0(24.3)	44.0(13.1)	33.0(9.8)	37.6(11.2)	24.8(7.4)	30.3(9.0)	337
1993	49.0(19.5)	45.6(18.2)	32.8(13.1)	27.1(10.8)	47.8(19.0)	18.7(7.5)	29.9(11.9)	251
1994	84.0(20.6)	99.7(24.4)	57.5(14.1)	36.1(8.9)	59.4(14.6)	29.6(7.3)	41.7(10.2)	408
1995	80.6(30.2)	44.5(16.7)	38.4(14.4)	39.4(14.8)	24.7(9.3)	19.3(7.2)	20.1(7.5)	267
1996	66.8(18.6)	78.3(21.8)	68.2(18.9)	40.2(11.2)	39.2(10.9)	21.5(6.0)	45.8(12.7)	360

[a] Corrected based on Hamlin et al. (2000).

[b] Corrected based on differential mortality rate by age – see Reproduction and Mortality Chapter.

[c] Corrected number (corrected percent).

Table 6.10. Full age structure of hunter-killed female elk based on incisor cementum annuli, Gravelly-Snowcrest Mountains, 1989-1996.

Age	Year								
	1989	1990	1991	1992	1993	1994	1995	1996	Total[a]
1	60(21.5)[b]	50(21.9)	61(20.0)	73(21.7)	41(16.3)	71(17.4)	69(25.8)	56(15.6)	20.0
2	47(16.9)	50(21.9)	56(18.4)	79(23.4)	43(17.1)	95(23.3)	43(16.1)	74(20.6)	19.7
3	42(15.1)	31(13.6)	36(11.8)	48(14.2)	35(13.9)	62(15.2)	42(15.7)	73(20.3)	15.0
4	25(9.0)	23(10.1)	35(11.5)	36(10.7)	29(11.6)	39(9.6)	43(16.1)	43(11.9)	11.3
5	26(9.3)	19(8.3)	21(6.9)	20(5.9)	32(12.8)	34(8.3)	19(7.1)	25(6.9)	8.2
6	15(5.4)	21(9.2)	15(4.9)	21(6.2)	19(7.6)	30(7.4)	8(3.0)	17(4.7)	6.1
7	16(5.7)	6(2.6)	20(6.6)	17(5.0)	9(3.6)	18(4.4)	11(4.1)	13(3.6)	4.5
8	14(5.0)	8(3.5)	9(3.0)	10(3.0)	11(4.4)	14(3.4)	10(3.8)	10(2.8)	3.6
9	3(1.1)	5(2.2)	6(2.0)	9(2.7)	5(2.0)	12(2.9)	6(2.3)	6(1.7)	2.1
10	5(1.8)	3(1.3)	9(3.0)	4(1.2)	11(4.4)	10(2.5)	2(0.8)	5(1.4)	2.1
11	7(2.5)	5(2.2)	10(3.3)	5(1.5)	2(0.8)	4(1.0)	3(1.1)	11(3.1)	1.8
12	6(2.2)	2(0.9)	7(2.3)	5(1.5)	4(1.6)	5(1.2)	3(1.1)	4(1.1)	1.5
13	3(1.1)	0	2(0.7)	3(0.9)	1(0.4)	5(1.2)	0	3(0.8)	0.6
14	1(0.4)	2(0.9)	3(1.0)	0	2(0.8)	1(0.3)	3(1.1)	2(0.6)	0.6
15	2(0.7)	0	8(2.6)	2(0.6)	3(1.2)	5(1.2)	2(0.8)	4(1.1)	1.0
16	1(0.4)	0	0	0	3(1.2)	1(0.3)	1(0.4)	4(1.1)	0.4
17	1(0.4)	0	2(0.7)	0	0	1(0.2)	0	6(1.7)	0.4
18	1(0.4)	1(0.4)	4(1.3)	4(1.2)	0	1(0.2)	1(0.4)	2(0.6)	0.6
19	3(1.1)	1(0.4)	0	1(0.3)	1(0.4)	0	1(0.4)	2(0.6)	0.4
20	1(0.4)	0	1(0.3)	0	0	0	0	0	0.1
21	0	1(0.4)	0	0	0	0	0	0	0.1
N	279	228	305	337	251	408	267	360	2435

[a] Percent in this column is mean percent for 8 years, not a sum of numbers/total numbers.

[b] Number(%).

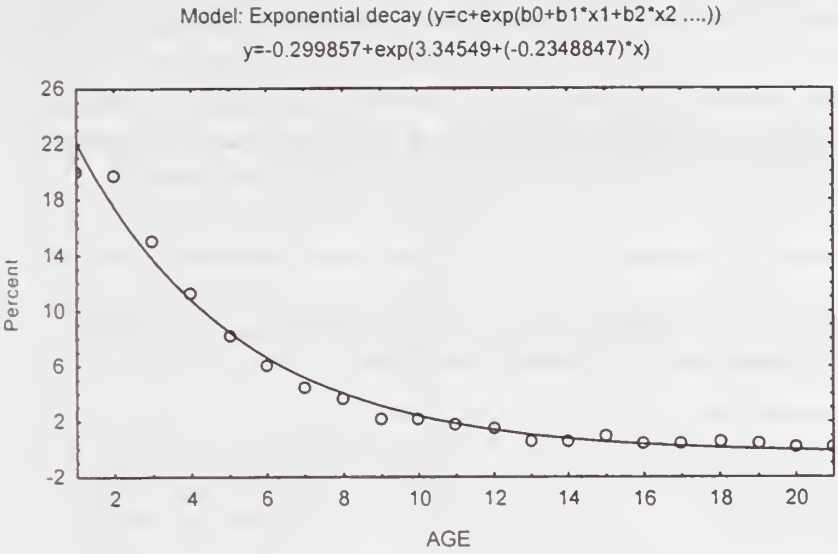


Figure 6.1. Exponential decay model for adult female elk age structure, Gravelly-Snowcrest Mountains, 1989-1996.

Although the number of antlerless elk harvested increased considerably from 1984 through 1996, we did not observe a substantive change in adult female age structure during the period (Tables 6.8 and 6.10). The low calf survival reported for the 1980 cohort (Tables 6.2, 6.4, and 6.5) was not readily apparent at the 4-year-old age class in 1984 (Tables 6.8 and 6.9). This 4-year-old class was actually the largest by percentage of any recorded (Tables 6.8 and 6.9). Poor survival of the 1995 calf cohort, however, was apparent as a low percentage of yearlings in the 1996 harvest (Tables 6.8 and 6.9). With relatively heavy harvest rates, differences in cohort size may be smoothed out by 4 years of age. It is also possible that the calf cohorts of 1979 and 1980 (age class 5-6, 1985, Tables 6.8 and 6.9) did not have unusually poor survival, however classifications indicated few yearling bulls in 1980 and 1981 (Tables 6.3, 6.4, and 6.5).

Age structure data (Tables 6.8 and 6.9) indicated that survival of the 1994 cohort was high. This carried through to the 2-year-old level indicating that classifications and mortality recorded for radio-collared calves of the 1994 cohort did not represent the population.

Regulations for hunting bulls changed in piecemeal fashion over the study area during 1981-1987, making some analyses difficult. Greater portions of the area were gradually included under BAB regulations over the period, but one portion remained open to harvest of any antlered bull through 1989. Age structure of adult males in the harvest changed as a function of regulation. The percent of yearlings in the bull harvest recorded at check stations during 1984-1989 was 34.0%, 37.8%, 27.7%, 28.4%, 28.6%, and 20.0%, respectively. Mean percent of yearlings in the bull harvest was 29.4% (28.5% of total numbers). From 1990 to the present, except for rare brow-tined yearlings and illegal kills, yearling bulls were 0% of the harvest by regulation. To compare age structure of bulls in the harvest between BAB and BTB periods, we used only bulls ≥ 2 years old, legal to harvest throughout the period.

The percent of adult bull harvest ≥ 3 years old ranged between 13.3% and 30.9%, averaging 23.8% (Table 6.11). Bulls ≥ 4 years old averaged only 4.4% of the total. The highest proportions of older bulls were harvested during 1991,1994, and 1996, when severe weather forced elk to low elevations early in the hunting season. This early severe weather also apparently resulted in movement of long-distance migrants from Yellowstone National Park and Idaho to Montana early in the hunting season, making them vulnerable to hunters for longer than usual.

Table 6.11. Ages of hunter-killed male elk based on incisor cementum annuli or corrected[a] eruption–wear estimates, Gravelly-Snowcrest Mountains, 1984-1996.

	Age								
Year	1	2	3	4	5	6	7	≥8	Total
1984	16	26.9(86.7)[b]	4.0(12.9)	0.1(0.4)					31
1985	34	41.8(74.6)	11.2(20.0)	2.4(4.3)	0.5(0.9)	0.1(0.2)			56
1986	33	65.7(76.4)	17.0(19.7)	2.7(3.1)	0.5(0.6)	0.1(0.2)			86
1987	40	75.0(74.2)	21.8(21.6)	2.8(2.8)	1.0(1.0)	0.2(0.2)	0.1(0.1)		101
1988	36	66.9(74.0)	19.4(21.5)	2.8(3.1)	0.2(0.2)	0.7(0.7)	0.5(0.6)		90
1989	23	70.6(76.8)	16.2(17.6)	1.1(1.2)	2.0(2.2)	1.0(1.1)		1.0(1.1)[c]	92
1990	3	61.9(81.5)	11.5(15.2)	2.5(3.3)	tr(tr)[d]	tr(tr)			76
1991	0	99.5(69.1)	35.6(24.7)	5.8(4.0)	2.1(1.4)	1.1(0.7)			144
1992	2	98.4(85.5)	15.3(13.3)	1.3(1.2)					115
1993	0	93.9(82.4)	17.3(15.2)	2.7(2.4)	tr(tr)	tr(tr)			114
1994	2	138.0(71.5)	47.8(24.8)	5.1(2.7)	1.0(0.5)	tr(tr)	1.0(0.5)		193
1995	1	61.3(77.5)	13.1(16.6)	3.3(4.2)	1.4(1.8)				79
1996	3	108.3(71.2)	34.7(22.8)	7.0(4.6)	2.0(1.3)	tr(tr)			152

[a] Corrected based on techniques reported in Hamlin et al. (2000).

[b] Corrected number (corrected percent), numbers rounded to 1 decimal place, calculations based on 2 decimal places. Percentages for elk ≥2 years old only.

[c] 9 years old.

[d] tr (tr) = < 0.1.

Proportions of bulls harvested in age classes 2-9 (Table 6.12) were not different ($\chi^2_7 = 6.9$, $P <$ 0.444) between those subject to BAB and BTB regulations as yearlings. Years with the highest proportions of bulls ≥ 3 years old in the harvest age structure all occurred under BTB regulations. However, those years were balanced by following years when, because of the previous heavy harvests, fewer older bulls were available. Thus, ages of hunter-killed bulls did not necessarily represent standing age structure each year.

Bulls examined at check stations for which the hunters did not pack out a mandible seemingly were disproportionately composed of bulls > 2 years old. Recognizing that ages based on antler size are problematic, we tried to incorporate these bulls into an analysis of potential changes in age distribution of the harvest. Two-year-old bulls were relatively easy to classify to age by antler length, shape, mass, and configuration of points. For other bulls, we used summaries of

Table 6.12. Percent distribution of ages of hunter-killed male elk compared between branch-antlered bull (BAB) and brow-tined bull (BTB) seasons, Gravelly-Snowcrest Mountains, 1984-1996.

	Hunting Season		
Age	BAB(1984-1990)[a]	BTB(1991-1996)[b]	Total(1984-1996)[c]
2	76.8	75.2	75.8
3	19.0	20.6	19.9
4	2.7	3.2	3.0
5	0.8	0.8	0.8
6	0.4	0.1	0.3
7	0.1	0.1	0.1
8	0	0	0
9	0.2	0	0.1

[a] n = 7 years, 532 bulls.
[b] n = 6 years, 797 bulls.
[c] n = 13 years, 1329 bulls.

antler length, number of points, shape, and mass for known-age bulls to proportionally place bulls for which mandibles were not available into categories of 3- and 4 years and older. Even with inclusion of these data (Fig. 6.2), percent of bull harvest ≥ 3 years old and percent ≥ 4 years old did not change during 1985-1996. Slope of the regression line for percent of bull harvest ≥ 3 years old plotted against year was not different from zero ($r = 0.026$, $F_{10} = 0.007$, $P < 0.936$). Similar results occurred for percent of bull harvest ≥ 4 years old ($r = 0.172$, $F_{10} = 0.304$, $P < 0.593$). From 1991-1996, weather factors (1991,1994,1996) and reduced numbers of older bulls (1992, 1995) following years of heavy harvest appeared to most influence percent of older bulls in the harvest (Fig. 6.2). As expected, including estimated ages based on antler points, mass and length, increased the estimated proportion of older bulls, but for all years. Percent of bulls ≥ 3 years old was essentially the same for the sample based only on examination of teeth (23.8%) and the sample that included age estimates based on antler characteristics (23.4%). However, for bulls ≥ 4 years old, the mean was 4.4% for those based only on examination of teeth and 7.8% for the sample that included ages estimated based on antler characteristics. This difference was significant ($t_{22} = 3.62$, $P = 0.002$). Older, larger bulls were more likely to be shot in difficult terrain, further from roads and mandibles were less likely to be packed out. This increased the relative percent of 2-year-olds in samples aged only by examination of teeth.

We also compared mean age (incisors, 1989-1996) of bull elk harvested among hunting districts in the Gravelly-Snowcrest Mountains. Mean age (sample size) was 2.44 (147), 2.22 (495), 2.29 (113), 2.44 (66), and 2.29 (130) for HDs 323, 324, 325, 327, and 330, respectively. Bull ages were significantly older in HD 323 ($P = 0.0004$) and HD 327 ($P = 0.007$) than HD 324. Small sample sizes may have resulted in no differences between HDs 323 and 327 and the other HDs. Older average ages of harvested bulls coincided with the most secure habitat from terrain, cover, and access standpoints.

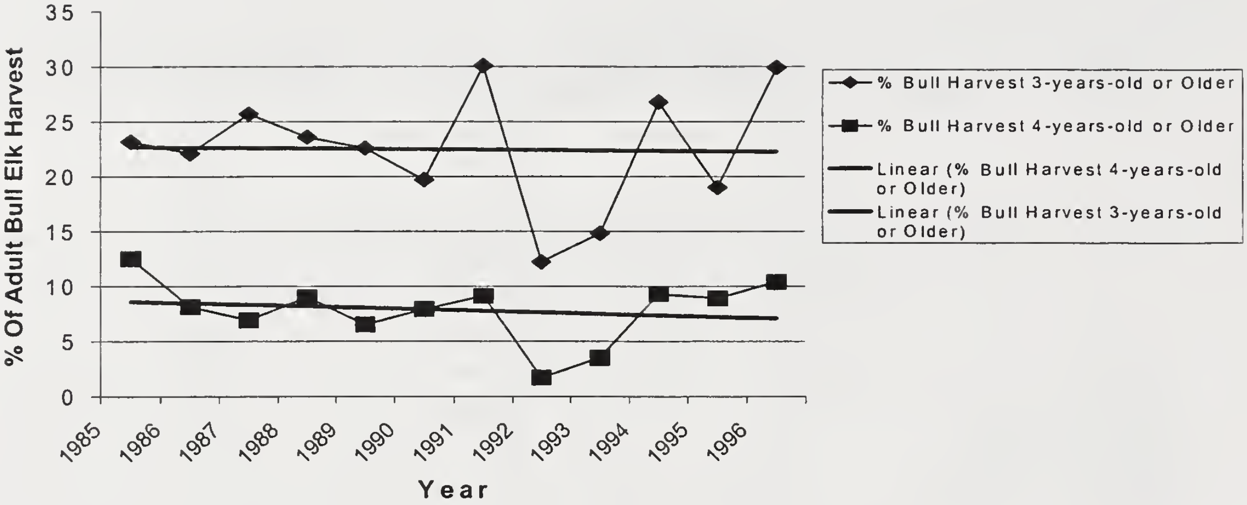


Figure 6.2. Percent of annual bull elk harvest ≥3 years old and ≥4 years old, Gravelly-Snowcrest Mountains, 1985-1996.

We used percent of harvested bulls with ≥6 x 6 point antlers (of those with at least 3 x 3 point antlers) as another index of older bulls to examine distribution of older bulls among hunting districts and between regulation types (Table 6.13). These data indicated that during 1985-1990, HDs 325 and 327 had the highest proportion of older bulls. Both HDs remained AB districts through 1986 and the southern portion of HD 327 remained an AB district through 1989. The proportion of 6 x 6 point bulls increased in all HDs except HD 325 during 1991-1997 compared to 1985-1990 (Table 6.13). During the later period, HDs 323 and 327 had the highest proportion of older bulls (Table 6.13). Again, these data indicated the highest proportion of older bulls in the HDs with the most secure habitat. However, in less secure habitat (HD 325) the proportion of older bulls declined as regulations changed from AB to BTB. Another factor contributing to harvest of older bulls in HD 327 is that it bordered an Idaho hunting district with light harvests after 1990. This Idaho district had a 1-2 week season of spike only hunting with very limited permits for branch-antlered bulls after 1990.

The proportion of older bulls (based on antler points) increased significantly (*P* = 0.0008) in HD 323 and for the entire area during the period of BTB regulations (Table 6.13).

Table 6.13. Proportion of harvested bull elk that had ≥6 x 6 point antlers (of those with at least 3 x 3 antler points) compared among hunting districts and BAB and BTB hunting regulations.

Hunting District	BAB 1985-1990		BTB 1991-1997		Significance	
	Proportion	%	Proportion	%	χ^2	*P*
323	10/163	6.1	92/558	16.5	11.1	0.0008
324	24/321	7.5	122/1278	9.6	1.32	0.25
325	13/94	13.8	68/643	10.6	0.89	0.35
327	34/210	16.2	143/772	18.5	0.61	0.44
330	13/147	8.8	89/773	12.1	0.89	0.34
Total	94/935	10.1	514/4024	12.8	5.22	0.02

Spike bull elk likely mistaken for a cow. Antlers about half length of ear.

Yearling bull (2-point) illegally killed during BTB hunting season.

CHAPTER 7

REPRODUCTION AND MORTALITY

Reproduction

Pregnancy rate averaged 38.6% for female elk breeding at age 1, 92.5% for age 2, 97.7% for ages 3 to 8, and 90.0% for ages ≥9 years (Table 7.1). With our sample sizes, the only significant differences among ages were 1 vs 2 years ($\chi^2_1 = 39.0$, $P < 0.000$), 1 vs 3-8 years ($\chi^2_1 = 116.3$, $P < 0.000$), and 1 vs ≥9 years ($\chi^2_1 = 19.1$, $P < 0.000$). Other potential differences among ages were 2 vs 4-8 years ($\chi^2_1 = 3.6$, $P = 0.059$), 2 vs 3-8 years ($\chi^2_1 = 3.3$, $P = 0.07$), 4-8 vs ≥9 years ($\chi^2_1 = 3.5$, $P = 0.061$), and 3-8 vs ≥9 years ($\chi^2_1 = 3.0$, $P = 0.08$). Generally, yearlings were the lowest producers, 2-year-olds and those ≥9 years old were substantially higher, and 3- to 8-year-olds were pregnant at the highest rate.

Similar differences by age class were observed in other Montana elk populations. However, pregnancy rate was generally higher for the Gravelly-Snowcrest elk population than for other areas. For 7 Montana areas combined over many years, 29.8% of 168 1-year-olds, 94.3% of 685 2- to 8-year-olds, and 72.8% of 103 elk ≥9 years old were pregnant (MFWP unpupl., Hamlin unpubl.). For the Gallatin and Northern Yellowstone populations combined during the 1960s, 14% of 1-year-olds, 96-99% of 2- to 9-year-olds, 91% of 10- to15-year-olds, and 35% of 16- to 21-year-olds were pregnant (Greer 1965, 1966). For the Sun River elk population, 78% of females ≥2-years-old were pregnant (Knight 1970). Lemke (2000) reported that for the Northern Yellowstone elk population, pregnancy rate for 1-year-old cows averaged 8.2% from 1986-2000 and ranged from 1.5-13.8%. During the same period, pregnancy rate for cows ≥2-years-old ranged from 47.2-78.2 % and averaged 70.7%.

Only 8 reproductive tracts were collected during our study. Mean conception date was 25 September, with a range of 33 days from 8 September to 11 October. Assuming a gestation of 247 days (Morrison et al. 1959) this sample indicated birth dates ranging from 13 May to 15 June, with a mean of 30 May. We were in the field only infrequently during the calving period, so earliest and latest births recorded by observation were not definitive. Numerous calves were present by the earliest date we observed newborn calves, 25 May in both 1993 and 1994. This indicated that at least during some years, calving was well underway by that time. Reichelt (1973) reported a newborn calf in the West Fork of the Madison River area on 17 May during 1972. The latest newborn observed during the study was on 18 June 1985. Also, we captured a spotted calf on 2 March 1988, indicating birth in late November. This exceptionally late calf survived to be shot as a 2-year-old in 1989. Two hunters reported late-term fetuses in females shot during late October.

No indication of late conception was noted in the Gravelly-Snowcrest Mountains (Fig. 7.1), although the sample was small. Mean conception date was earlier in the Gravelly-Snowcrest Mountains than for 11 other Montana elk population/year samples and later than for 5 (Fig. 7.1). These populations, including those with later mean dates of

Table 7.1. Pregnancy rate of elk by age or age category in the Gravelly-Snowcrest Mountains, Montana, 1984-1994.

Age[a]	Individual Age	5 Age Categories	2 Age Categories
1	38.6 (83)[b]	38.6 (83)	38.6 (83)
2	92.5 (53)	92.5 (53)	95.7 (254)
3	96.6 (58)	97.7 (173)	
4	100 (39)		
5	100 (26)		
6	100 (24)		
7	88.9 (9)		
8	100 (12)		
9	80.0 (5)	90.9 (22)	
10	100 (5)		
11	- (0)		
12	83.3 (6)		
≥13	100 (5)		
Unk. ≥2	83.3 (6)	83.3 (6)	

[a] Age at breeding.

[b] % pregnant (sample size).

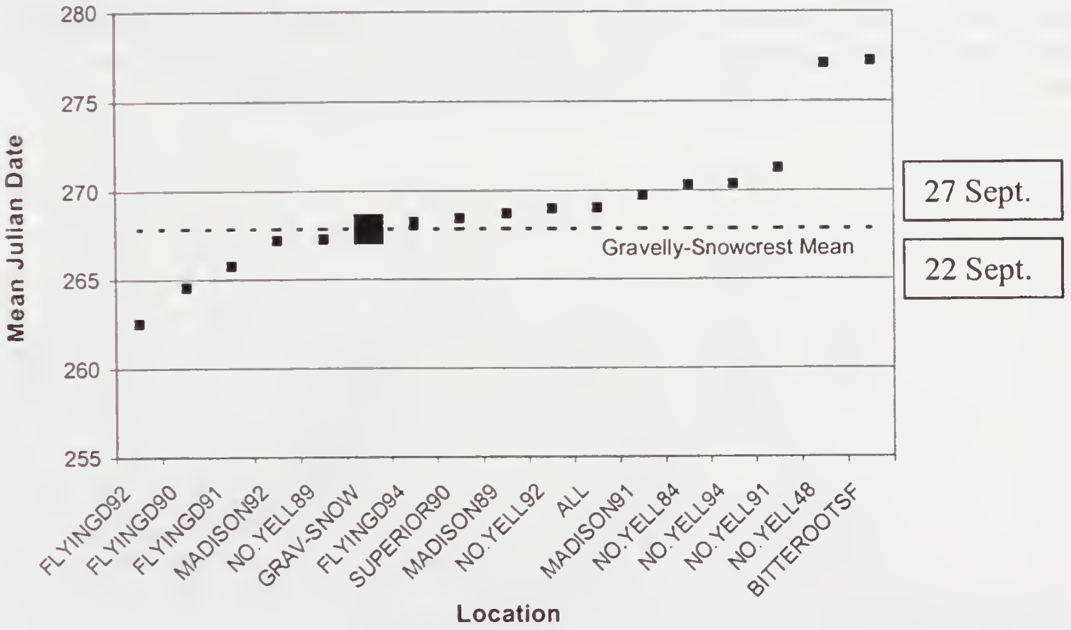


Figure 7.1. Mean Julian date of conception for various elk population/years in Montana. Elk population is followed by last 2 digits of year (FLYINGD92 = Flying D Ranch 1992). Sample size for the Gravelly-Snowcrest population was 8; for other areas sample size ranged from 22-248 (MFWP files, K. Alt, B. Henderson, T. Lemke, pers. comm.).

conception, generally had much higher bull:100 cow ratios than we observed in the Gravelly-Snowcrest Mountains.

We also used diastema length of hunter-killed calves as an index of growth and birth date. We assumed that earlier born (older) calves would have longer diastemas. For this examination, we used only female calves because sample size of males was too small to compare among years. Ninety-five percent confidence intervals of means of diastema length of female calves overlapped for all years and ANOVA ($F_{12,669} = 1.20$, $P = 0.28$) indicated no significant difference among years. Distribution of diastema length (birth date) basically followed a bell shaped curve each year with minor exceptions, probably due to sample size (Figs. 7.2, 7.3, and 7.4). Exceptions to a bell shape were generally skewed to later born calves, but there was no indication of substantial breeding during a second estrus. A possible exception may have occurred in 1994 (1993 breeding, Fig. 7.4). Most years had about as many early births as late births. Diastema lengths more than 2 SD above the mean (early births) were 2.7% of the sample and diastema lengths more than 2 SD below the mean (late births) were 3.8% of the sample. Similar figures for more than 1.5 SD above and below the mean were 5.2% and 6.7%, respectively.

We also examined diastema length of all hunter-killed calves (males and females combined) for each year. Median value (82-83 mm) was the same each year 1985-1996, except for 1990 (Fig. 7.5), which had a median value of 84-85 mm indicating earlier births/faster growth that year. Neither this information nor the data displayed as a histogram (Fig. 7.6) indicated a second peak in birth dates that could be interpreted as breeding during a second estrus. Both plots indicated a bell-shaped distribution slightly distributed toward later born calves, which would be expected given the relatively high pregnancy rate of yearling cows in the Gravelly-Snowcrest Mountains.

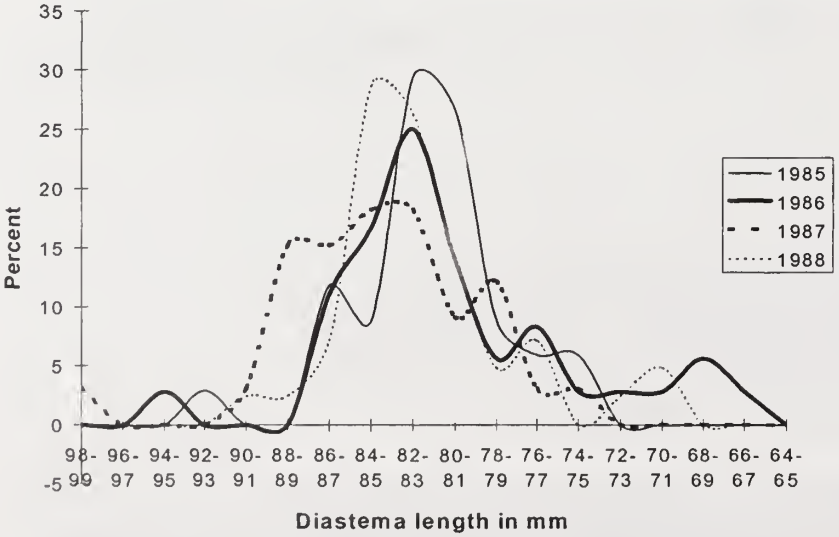


Figure 7.2. Smoothed curves of diastema length for hunter-killed female elk calves, Gravelly-Snowcrest Mountains, 1985-1988. Longer diastema length (left side of Figure) represents earlier born calves.

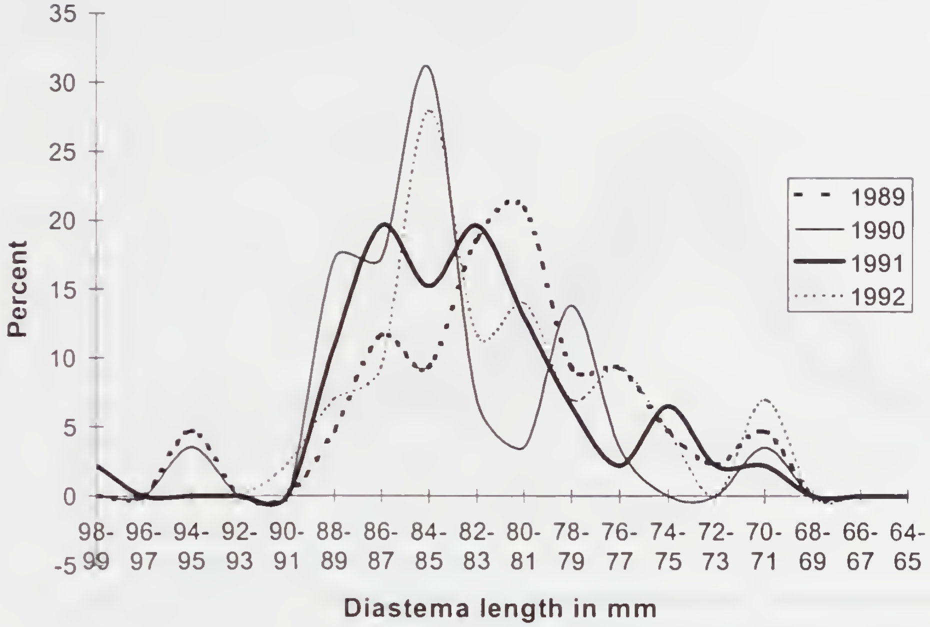


Figure 7.3. Smoothed curves of diastema length for hunter-killed female elk calves, Gravelly-Snowcrest Mountains, 1989-1992. Longer diastema length (left side of Figure) represents earlier born calves.

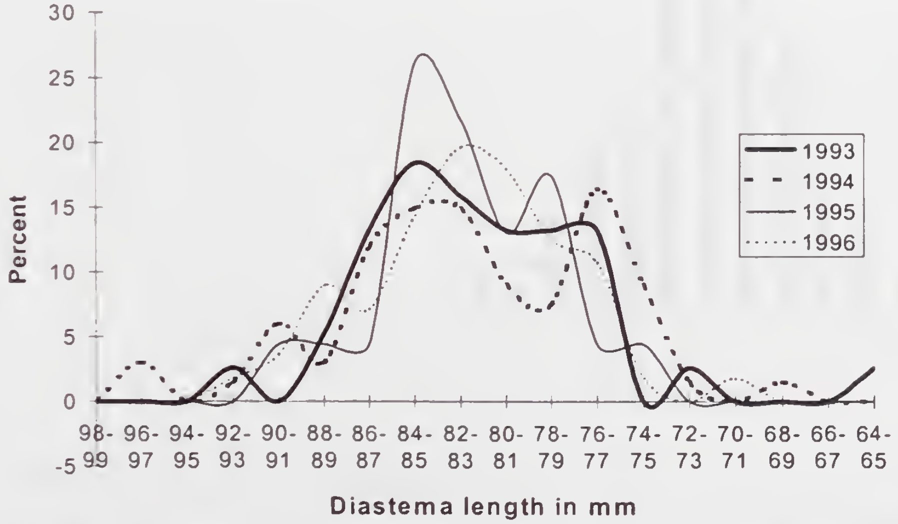


Figure 7.4. Smoothed curves of diastema length for hunter-killed female elk calves, Gravelly-Snowcrest Mountains, 1989-1992. Longer diastema length (left side of Figure) represents earlier born calves.

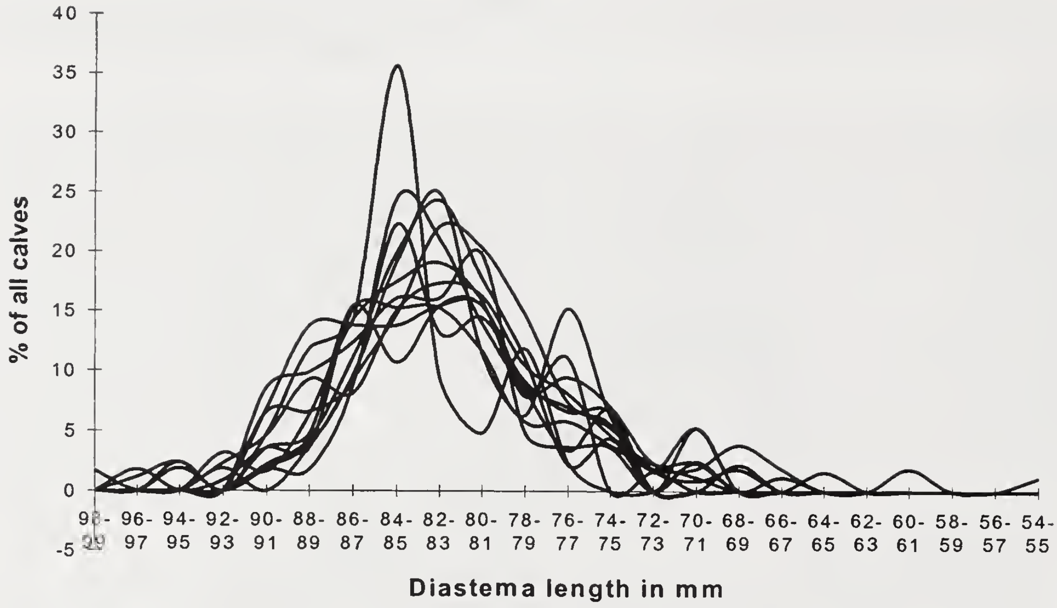


Figure 7.5. Annual smoothed plots of diastema lengths of all hunter-killed elk calves, Gravelly-Snowcrest Mountains, 1985-1996.

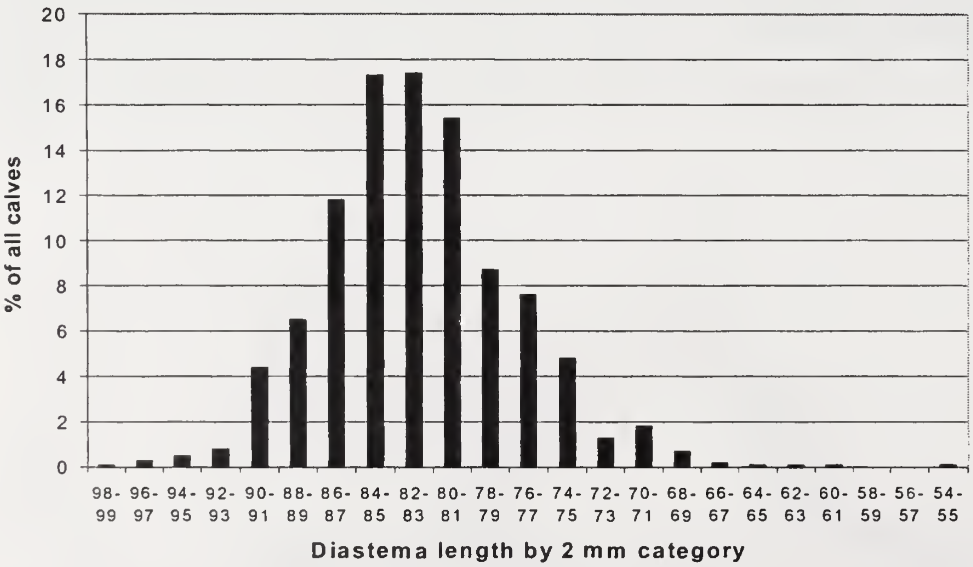


Figure 7.6. Distribution of diastema length for all hunter-killed elk calves, Gravelly-Snowcrest Mountains, 1985-1996.

Our method of using diastema length to represent birth date may not detect many late births if they occurred. Late born calves may not survive in substantial numbers to be harvested and appear in the sample. Also, hunters may select against small calves that did survive. However, our other observations did not support the premise that many late births occurred. A few late born calves were observed every year, but no more than might be expected in any population. When we made note of late born calves during late July helicopter classifications in 1989, 1990, and 1996, only 5 (0.4%) of 1,437 calves were classified as late born. Also, we did not observe elk behavior during radio-relocation flights that indicated significant late birthing during any year.

We calculated potential calf production at birth pulse given the observed age-specific pregnancy rates and adult female age structure. Observed calf survival was used to partition age of the cow population into those breeding as calves (no production), yearlings (0.386 calves:cow), and ≥2 years old (0.957 calves:cow)(Table 7.1). We calculated new yearling cows (those potentially breeding as calves) by dividing calf recruitment rates by 2 (assumed 50% female calves). Cows that previously were yearling and ≥2 year olds were reduced by their average annual mortality rate. At sustained late winter recruitment of 35, 45, and 55 calves per 100 cows, 74, 70, and 67 calves per 100 cows, respectively, would be expected at birth pulse. We can use either the mean of 70 calves:100 cows or a number within the range of 67-74 calves:100 cows as a baseline to calculate annual calf mortality/survival when compared to observed annual calf :100 cow ratios during late winter – spring. Thus, observed calf recruitment of 55:100 implied 55/67 = 82% annual survival. Sustained recruitment of 35 calves:100 cows implied 35/74 = 47% annual survival. At 75 males:100 females recruited, 71, 66, and 62 calves:100 cows would be expected at sustained recruitment of 35, 45, and 55 calves per 100 cows, respectively. Estimated calf survival at those recruitment rates would be 49%, 68%, and 89%, respectively.

Mortality

Calves

During 1984-1988, 72 newborn calves (40 males and 32 females) were captured and equipped with radio-transmitter collars. Because of transmitter failure and slipped collars, 8 were censored and not included in samples for mortality. For the summer (birth- 31 Aug) sample, 8 (21.6%) of 37 males and 3 (11.1%) of 27 females died. Overall, mortality was 11(17.2%) of 64 calves. Deaths of 6 males and all 3 females were caused by starvation due to abandonment. We attributed 2 deaths of male calves (18.2% of all deaths) to black bear predation. A minimum of 2 of the 8 censored calves was known to have survived to be shot in subsequent hunting seasons. If we assume that all 6 other censored calves died during summer, a maximum mortality rate of 17 (23.6%) of 72 calves occurred. If these censored calves survived summer, a minimum mortality rate of 9 (12.5%) of 72 calves occurred. Thus summer mortality of calves for combined samples during 1984-1988 was 17.2%, but could have ranged between 12.5-23.6%. One of the 6 remaining censored calves survived into July, so would not have died due to abandonment. If we excluded deaths due to abandonment from the sample, 2 (3.6%) of 55 calves died during summer, both as a result of black bear predation. Thus, black bear predation was a major cause of mortality of elk calves during summer, but occurred at a low rate.

We questioned whether the abandonment we recorded was natural or related to capture and handling. Some natural abandonment does occur and first time mothers may be more susceptible to this. However, 5 of the 6 calves that were classified as abandonments weighed 21-33 kg (46-73 lbs) at capture. This indicated abandonment caused by capture because they had survived and grown for a week or more until captured. It is possible that the mortality we observed, which may have included unnatural abandonment, by chance equaled mortality for the entire calf population. The unnatural abandonment mortality may have numerically equivalent to undetected mortality that occurred within a day or two of birth, before most calves were captured.

Multiplying sex-specific survival rate by the sex ratio of the newborn sample (125 males:100 females) resulted in a surviving sex ratio of 110 males:100 females entering the hunting season. If, with a larger sample size, the sex ratio at birth was 100 males: 100 females, the surviving sex ratio of calves entering hunting season would be 88 males: 100 females.

Deaths in this sample during the hunting season (1 Sept – 30 Nov) were 3 (13.6%) of 22 males and 1 (5.9%) of 17 females or 4 (10.3%) of 39 total. All deaths were the result of hunter harvest. Sex ratio at the end of hunting season as calculated for summer would be 101 or 81 males:100 females, depending on the original sex ratio. The latter ratio, derived from a 100:100 sex ratio at birth, resulted in a calf sex ratio at the end of hunting season similar to the ratio we observed for drive-net captured calves (76 males:100 females). All 13 male and 11 female calves in the sample at 1 Dec survived winter-spring (1 Dec – 30 May). Maximum annual survival was 29 of 40 (0.725) for male calves and 28 of 32 (0.875) for female calves. Minimum annual survival, including known fates of censored calves was 21 of 40 (0.525) males and 17 of 32 (0.531) females. The combined evidence indicated that male calves died at a greater rate than female calves during their first year, but the differences were not statistically significant for our small sample.

Calves were captured and equipped with radiocollars during December 1992 and February-March during most other years 1984-1995. We used surviving newborn calves and these winter-captured calves to monitor survival during winter (Table 7.2). Survival of elk calves was high during winter for the study period. For years other than 1995, survival averaged 0.987. Survival of the calves captured during 12-13 March 1995 was 26/36 (0.722). We were concerned that the unusual mortality during spring 1995 may have been related to some capture-related factor. Sex/age classifications that winter-spring indicated that calf mortality may have occurred population-wide at the rate recorded for the radiocollared sample, or higher. However, age structure of the 1995 and 1996 harvests did not reconcile with high calf mortality during winter 1994-1995. Thus, mortality we observed for radiocollared calves during winter 1994-1995 possibly was influenced by capture.

Causes of death (Table 7.3) were predation, malnutrition, or a combination of those factors. Reasons for the increase in mortality during 1995 are unknown. However, because calf mortality occurred late in winter 1994-1995, and production of new calves was low by mid-July 1995, we suspected malnutrition as the major contributing factor. Some increased predation also may have occurred beyond that predisposed by malnutrition. At least 2 of the deaths attributed to mountain lion predation did not appear to be related to malnutrition. It is possible that calves captured in March 1995 were made vulnerable to predation because of capture myopathy. In that case, overwinter survival of calves was higher than reported in Table 7.2. In any case, minimum winter survival rate for radiocollared elk calves during 1984-1995 was 0.95.

Table 7.2. Monthly survival during winter for radio-transmitter collared elk calves, 1984-1995.

Sex	Month					
	January	February	March	April	May	Total
Males	27/27[a] (1.00)	27/27 (1.00)	212/217 (0.977)	230/234 (0.983)	228/230 (0.991)	(0.952)
Females	23/23 (1.00)	23/23 (1.00)	41/43 (0.954)	50/50 (1.00)	50/50 (1.00)	(0.954)
Total	50/50 (1.00)	50/50 (1.00)	253/260 (0.973)	280/284 (0.986)	278/280 0.993)	(0.953)

[a] number of survivors/sample size (survival rate)

Table 7.3. Causes of death recorded for radio-transmitter collared elk calves, 1984-1995.

Month	Number – Cause of Death	Remarks
March	4 – Mountain lion predation 1 – Malnutrition 1 – Unknown predator 1 – Probable wolf kill	-1 FMF <20%, 2 FMF >70%, 1 FMF unk.[a] -FMF <10% -Rt. eye blind before capture(1994),FMF>70% -1993, BTWMA
April	3 – Mountain lion predation 1 – Black bear predation or scavenged	-No data for FMF -FMF <10%
May	1 – Malnutrition, tangled in fence 1 – Unknown, consumed by Black bear	-FMF <10% -1993

[a] FMF = Femur marrow fat, visually estimated based on previous experience with chemically measured values (Hamlin and Mackie 1989).

Adult Females

Annual mortality rates of radiocollared adult female elk were relatively high during most years (Table 7.4). The reported rates give a general sense of annual mortality/survival, but because the annual samples with transmitters were small in a relative sense (0.5-1.75% of adult cow population), actual rates may vary by several percentage points from observed rates (Table 7.4). Composite rates for the entire 13-year period (0.148 annual and 0.135 harvest) and for the 9-year-period of best distribution of the sample (0.173 annual and 0.158 harvest) are likely close to the actual figures (Table 7.4). Excluding 1984-1987 when the samples were primarily confined to one winter range, the range of annual mortality observed was 0.111-0.298 (survival = 0.702-0.889) and the range of hunting mortality was 0.107-0.298 (survival = 0.702-0.893). Survival rates calculated using the binomial estimator with a variance VAR (S) = S (1-S)/n (White and Garrott 1990) allowed computation of 95% confidence intervals for survival. Confidence intervals ranged from ± 0.008 in 1989-1990 to ± 0.024 in 1996-1997.

Table 7.4. Mortality rates and causes for radio-transmitter collared adult female elk, Gravelly-Snowcrest Mountains, 1984-1985 through 1996-1997.

					MONTANA							IDAHO			
Year[a]	N Annual	N Hunting	N(rate) Annual Deaths	N(rate) Hunting Deaths	General Season Harvest	General Season Wounding Loss	Shot And Not Reported	Archery Harvest	Archery Wounding Loss	Harvest Off Study Area	Total	Idaho Harvest	Idaho Wounding Loss		Unknown Natural Loss
1984-85[b]	25	25	1(0.040)	1(0.040)	1	0	0	0	0	0	1	0	0		0
1985-86[b]	51	50	5(0.098)	4(0.080)	0	1	0	0	0	1	2	1	1		1
1986-87	55	63	2(0.036)	2(0.032)	2	0	0	0	0	0	2	0	0		0
1987-88	62	63	11(0.177)	11(0.175)	7	0	1	0	0	1	9	2	0		0
1988-89	60	63	9(0.150)	9(0.143)	8	0	0	1	0	0	9	0	0		0
1989-90	83	89	12(0.145)	11(0.124)	7	2	2	0	0	0	11	0	0		1
1990-91	61	65	10(0.164)	9(0.139)	5	2	1	0	1	0	9	0	0		1
1991-92	56	58	13(0.232)	12(0.207)	10	1	1	0	0	0	12	0	0		1
1992-93	53	55	7(0.132)	7(0.127)	5	2	0	0	0	0	7	0	0		0
1993-94	52	56	6(0.115)	6(0.107)	5	1	0	0	0	0	6	0	0		0
1994-95	47	47	14(0.298)	14(0.298)	6	4	2	1	0	1	14	0	0		0
1995-96	35	35	6(0.171)	5(0.143)	4	1	0	0	0	0	5	0	0		1
1996-97	27	27	3(0.111)	3(0.111)	3	0	0	0	0	0	3	0	0		0
TOTAL	667	696	99(0.148)	94(0.135)	63	14	7	2	1	3	90	3	1		5(0.008)
TOTAL 1987-88 through 1995-96	509	531	88(0.173)	84(0.158)	57	13	7	2	1	2	82	2	0		4(0.008)

[a] Year = 1 June first year – 30 May second year.

[b] Elk marked only on WCWMA and Cherry-Morgan winter range these years.

Average annual rate of wounding loss to the adult female population was 0.024 and annual rate of natural mortality was 0.008 (Table 7.4). Hunting related causes of death accounted for 94 (95.0%) of 99 deaths (Table 7.4). Four (4.3%) of 94 hunting related deaths and 4 (4.0%) of 99 total deaths occurred in Idaho.

On balance, hunters possibly avoided shooting collared elk, thus mortality rates we report here may be minimums. However, some hunters reported wanting to shoot a marked elk so they could receive the home range map and history of the elk we sent to hunters who reported shooting a marked elk. For bull elk, with black collars, most hunters, including archery hunters, reported being unaware that the elk was collared at the time they shot. We believe that selection against shooting collared elk was not substantial and that reported mortality rates based on radiocollared elk were near the "true" population rate.

Elk that were shot and not reported were those for which evidence indicated that the carcass was removed from the field during a legal hunting season, but the collar was left in the field and not reported to MFWP. A portion of these may be reported on the postseason statewide harvest questionnaire (SWHQ), some may not be reported, and some may be illegal kills (the individual did not hold an antlerless permit). Thus, to relate other sources of mortality to harvest reported on the SWHQ, we use a range from all of these reported to none reported. Similarly, the range included assumptions that none to all of elk shot in other HDs and in Idaho were balanced by elk from those areas reported as shot within the study area. The harvest figure reported on the SWHQ must be multiplied by 0.200-0.239 (wounding loss as a proportion of reported harvest) to estimate average numerical wounding loss for adult female elk in the Gravelly-Snowcrest Mountains population. Annual numerical natural mortality can be estimated by multiplying harvest reported on the SWHQ by 0.064-0.077 (natural mortality as a proportion of reported harvest). For an elk population in Colorado with similar hunting regulations, Freddy (2000) estimated that reported legal harvest should be multiplied by 0.329 to estimate wounding loss for adult females and by 0.157 to estimate natural mortality. The higher wounding loss there was consistent with the dense cover provided by the oakbrush – mountain shrub habitat type on portions of that area.

Cause of death was also determined for 199 adult cows marked only with neckbands or radiocollars that had ceased to function. Causes of death such as wounding loss and natural mortality are underestimated with these animals, but their fates can be used to represent geographic distribution of hunting related deaths. Combined, of 292 hunting-related causes of death of adult females during the study, 268 (91.8%) were in Gravelly-Snowcrest HDs, 5 (1.7%) were in other Montana HDs, 18 (6.2%) were in Idaho, and 1 (0.3%) was in Wyoming.

We examined susceptibility to harvest by age for adult females. Because natural mortality was very low (Table 7.4), we included neckbanded and censored radiocollared females in the sample during their first year of marking (Table 7.5). For this subsample, known deaths were corrected for wounding loss and unreported kill in the proportion observed for the radiocollared sample (Table 7.4). This sample was especially important to include because the small radiocollared sample of yearling females did not appear to represent the harvest rate observed for the entire population of yearling females.

The data (Table 7.5) indicated that hunting mortality for 2- and 3-year-old females was higher than for other ages. For our sample, only the differences between 1-and 3- year-old ($\chi^2_1 = 4.7$, $P = 0.03$) and 3- and ≥4- year-old ($\chi^2_1 = 3.85$, $P = 0.05$) females were significant. Age structure determined from harvest samples should be corrected for age-specific harvest bias to accurately represent population age structure. With large harvests, further correction is warranted to calculate pre- and post-season age structure. It is possible that with the small sample of 1-year-old transmitter-collared elk and our reliance on neckbanded and censored elk for this age group, harvest rates may be higher than estimated in Table 7.5. Thus, selection against yearling cows may be overestimated by our data. Freddy (2000), however, estimated an even lower harvest rate of yearling cows relative to older cows in Colorado.

Table 7.5. Estimated hunting mortality rate by age for marked female elk, Gravelly-Snowcrest Mountains, 1984-1997. Includes wounding loss and unreported kill.

						Mortality rate		
Age	Sample	No. Shot	No. Survived	Unknown fate	Total	Best Estimate	Min.[a]	Max.[a]
1	transmitters	1	43	0	44	0.023		
	NB and Cens.[b]	20	129	50	199			
	Corrected[c]	26.5	172.5	0	199			
	TOTAL	27.5	215.5	0	243	0.113	0.086	0.319
2	transmitters	14	71	0	85	0.165		
	NB and Cens.[b]	3	18	14	35			
	Corrected[c]	4	31	0	35			
	TOTAL	18	102	0	120	0.150	0.142	0.258
3	transmitters	17	76	0	93	0.183		
	NB and Cens.[b]	3	9	1	13			
	Corrected[c]	4	9	0	13			
	TOTAL	21	85	0	106	0.198	0.189	0.198
≥4	transmitters	61	411	0	472	0.129		
	NB and Cens.[b]	7	65	10	82			
	Corrected[c]	9.3	72.7	0	82			
	TOTAL	70.3	483.7	0	554	0.127	0.123	0.141
TOTAL	transmitters	93	601	0	694	0.134		
	NB and Cens.[b]	33	221	75	329			
	Corrected[c]	43.7	285.3	0	329			
	TOTAL	136.7	886.3	0	1023	0.134	0.123	0.197

[a] minimum assumes no other neckbanded or censored transmitter-collared females died of hunting related causes, maximum assumes that all females of unknown fate died from hunting related causes.

[b] neckbanded females and those whose transmitter collars had ceased functioning.

[c] known mortalities of neckbanded and censored females corrected by multiplying known deaths by 1.324 to estimate wounding loss and unreported kill in the same proportion as observed for the transmitter-collared sample.

We also were able to estimate age-specific mortality rates based on data from a cohort life table (Table 7.6). These data tend to slightly overestimate mortality of younger elk and underestimate mortality of older elk because we applied the natural mortality rate estimated from radiocollared elk equally to all age classes. These estimates (Table 7.6) included all mortality, but indicated the same pattern as determined for hunting mortality of marked elk (Table 7.5). Mortality increased from 1- through 3- to 4-year-old females and then declined somewhat for females ≥4-years-old. Mortality rate increased for females ≥10-years-old, however. Compared to rates determined for marked elk (Table 7.5), however, mortality rates were higher overall and especially so for 1- and ≥4-year-old females. This supported our conclusion that mortality rates estimated for marked elk were too low for 1- and ≥4-year-old females. They did support the general pattern of differential age-specific mortality, however.

Explanations for different susceptibility to harvest by age are speculative. Hunters may select larger bodied elk, explaining the increase in harvest rate from yearling to 3-year-old females (Tables 7.5 and 7.6). The reason that harvest rate for females ≥4-years-old is lower than for 3-year-olds is less clear. Perhaps experience by older females plays a role, resulting in more successful avoidance of hunters.

Harvest mortality rate also varied by herd range (Table 7.7). Harvest rate was lowest for elk associated with the WCWMA , Cherry-Morgan winter range, and Basin-Sage Creek winter range. Herd range for the WCWMA elk is the most heavily timbered and least roaded within the study area. Similar factors applied to the Cherry-Morgan herd range and hunter access was also restricted there by private land in some areas. Unless severe winter conditions start early, Basin-Sage Creek elk are in Idaho during much of Montana's hunting season. Harvest rate was heaviest for elk associated with the BTWMA and RLWMA. Proportionally more of these elk were associated with the relatively open and well roaded Ruby River drainage and the Centennial Valley, and with increased public access for hunters.

The availability of large annual samples of ages from harvested elk enabled us to compute mortality rates by life table analysis (Caughley 1977, Krebs 1978, DeYoung, 1989, and Zager and Leptich 1991). For this type of analysis, it is important that the age distribution be stable and that the rate of population increase be zero or known. These assumptions should at least be approximated (Caughley 1977). Our data (Tables 6.8, 6.9, and 6.10) indicated that for most of the time period involved, we could meet the assumption of a stable age distribution. Also, within the period of analysis, we could estimate the rate of population increase (r) from aerial trend surveys. We chose to bracket the rate of increase between values of $r = 0.032\text{-}0.065$ (see Population Numbers Chapter). Also, we could use the cohort analysis and telemetry data to adjust the age structure of hunter-killed elk to correct for hunter selection, thereby approximating standing age structure.

Table 7.6. Age-specific mortality rates for female elk in the Gravelly-Snowcrest Mountains based on a cohort life table constructed from ages recorded at hunter check stations and wounding and natural loss rates determined from transmitter-collared elk.

	Cohort[a]												
Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean1[b]	Mean2[b]
1-2	0.181	0.147	0.134	0.186	0.233	0.158	0.162	0.213	0.216	0.136	0.225	0.181	0.183
2-3	0.193	0.092	0.148	0.233	0.174	0.192	0.257	0.306	0.165	0.319	0.166	0.204	0.208
3-4	0.192	0.223	0.293	0.206	0.169	0.202	0.258	0.199	0.305	0.194	0.382	0.239	0.244
4-5	0.214	0.224	0.152	0.174	0.273	0.222	0.191	0.296	0.285	0.277		0.231	0.233
5-6	0.242	0.185	0.167	0.229	0.187	0.255	0.292	0.192	0.261			0.223	0.225
6-7	0.168	0.224	0.188	0.255	0.223	0.342	0.092	0.238				0.216	0.218
7-8	0.096	0.328	0.226	0.153	0.288	0.178	0.184					0.208	0.211
8-9	0.197	0.214	0.195	0.295	0.216	0.222						0.223	0.221
9-10	0.212	0.136	0.289	0.171	0.187							0.199	0.203
10-11	0.336	0.419	0.071	0.196								0.256	0.250
11-12	0.203	0.204	0.438									0.282	0.307
4-10												0.217	0.224
10-12												0.269	0.270

[a] Cohort = year of birth.

[b] Mean1 = mean of annual means for each age group. Mean2 = mean based on total raw number of deaths divided by total raw sample size for each age group for all years of data.

Table 7.7. Relative harvest rate of adult female elk by area of marking, Gravelly-Snowcrest Mountains, 1984-1997.

Area captured	1984-1997			1989-1997		
	Deaths	Elk years[a]	Harvest rate	Deaths	Elk years[a]	Harvest rate
WCWMA[b]	29	266	0.109	14	120	0.117
Cherry-Morgan	4	36	0.111	1	23	0.044
BTWMA[c]	30	187	0.160	20	95	0.211
RLWMA[d]	-	-	-	13	64	0.203
Warmsprings	-	-	-	5	34	0.147
Basin-Sage	-	-	-	4	33	0.121
Other[e]	-	-	-	8	37	0.216
ALL	63	489	0.129	65	406	0.160

[a] An elk year = an elk with a functioning radiocollar from 1 June through 31 May (or functioning at death if died during the period).

[b] Wall Creek Wildlife Management Area.

[c] Blacktail Wildlife Management Area.

[d] Robb-Ledford Wildlife Management Area.

[e] Blacktail Ridge, Axolotl Lakes, Greenhorns, Sweetwater Hills.

We used slopes from regression analysis of life table data (example, Fig. 7.7) to calculate average survival rates ($S=e^{\beta}$). Survival and mortality rates determined by this method (Table 7.8) did not vary substantially from those determined by radio-telemetry. Also, correcting ages for hunter selection and population growth did not substantially affect rates, especially for bulls. The rates determined from corrected ages most closely matched rates determined by radio-telemetry, however. Uncorrected values in a growing population overestimated mortality rate, as expected. Similar calculations could be made for other Montana elk populations provided they had age structure data determined from incisors (Hamlin et al. 2000) and some indication of trend in population growth (r) from trend flights. Hunter selection data from this study could be used, or might not be necessary where selection might not be as strong in more heavily timbered areas or where elk are scarcer than in the Gravelly-Snowcrest Mountains.

We also estimated average survival/mortality rates by use of a cohort life table analysis. This had the advantage that corrections for hunter selection and population growth rate were unnecessary. However, because we estimated wounding loss and natural mortality based on average data from telemetry and original cohort size was underestimated because of elk that remained alive, mortality estimates will tend to be biased somewhat above actual rates. We did make and include estimates of elk remaining alive for each cohort based on average previous cohort sizes, but these still provided underestimates for a growing population, biasing mortality rate higher. Estimates of mortality based on cohort life table analysis (Table 7.9) were near those estimated from telemetry and full life table analysis (Table 7.8). These estimates were closest to those based on raw ages from the full life table. Average mortality rate for 1983-1989 was 0.218 and that for 1990-1993 was 0.247. This difference was expected because hunting pressure was higher during the later period (more antlerless permits issued) and there were fewer years of data for the later cohorts. Size of original cohort would be most underestimated for cohorts with fewest years of data, biasing mortality higher. The similarity of mortality rates among cohorts indicated that once female elk reached 1 year of age, mortality might vary only with major changes in hunting pressure. Despite these high mortality rates, the elk population increased from 1983-1993.

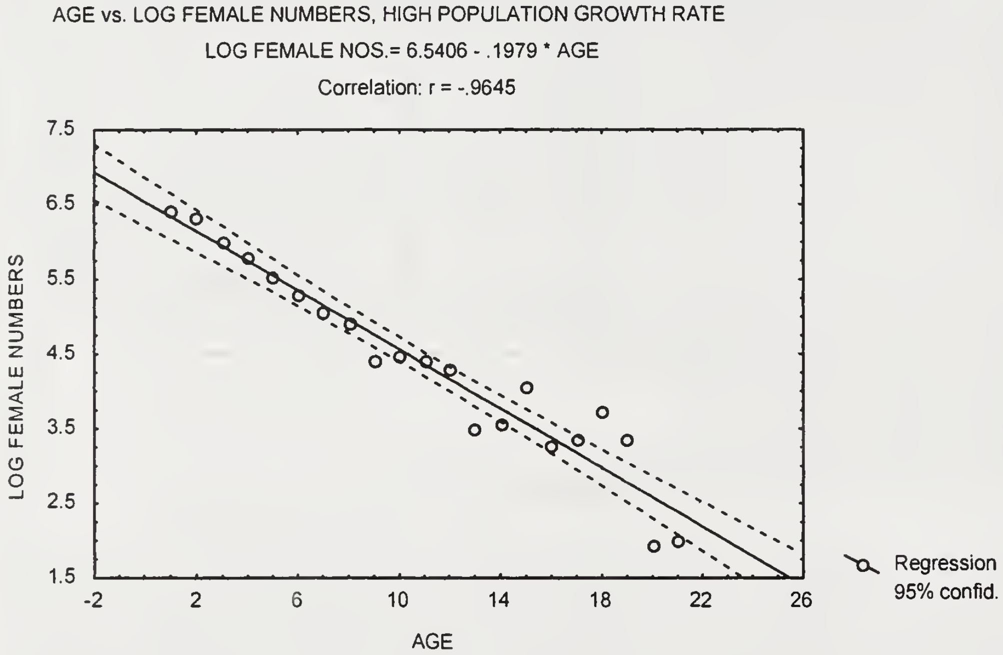


Figure 7.7. Regression equation used to determine mean survival/mortality rate for female elk ages 1 - 21 in the Gravelly-Snowcrest Mountains, 1989 - 1996. Data were based on mean age structure of hunter harvest corrected for hunter selection and a population growth rate of r = 0.065 [β(slope) = -0.198].

We also estimated annual and average mortality rates (Table 7.10) based on modeled population estimates (see Chapter 5, Population Numbers), estimated harvest loss from the Statewide Hunter Harvest Questionnaire, and average wounding and natural loss rates from telemetry data. These mortality estimates based on population estimates and the corrected SWHQ (Table 7.10) closely approximate the estimates derived from telemetry and age structure (Table 7.4 and 7.8). Mean estimates for survival/mortality of adult females for the entire period were: telemetry (0.824/0.176); age structure (0.794-0.820/0.206-0.180); cohort analysis (0.772/0.228) and; population estimates (0.820/0.180). All this gave us confidence that mortality, age structure, and population estimates we made were close to the “true” values.

Table 7.8. Survival and mortality rates for regressions of log of elk numbers against age for the hunter-killed sample, 1989-1996. Ages (females, 1-21 and males, 2-7) were also corrected for hunter selection and population growth and compared to telemetry determined mortality rates.

		R	R^2	F	*P*	β[a]	S[b]	M[c]
Ad. ♀♀	Telemetry[d]						0.824[d]	0.176[d]
	Raw ages Hunter-kill	0.979	0.958	437.8	<0.000	-0.260	0.771	0.229
	Corrected for hunter selection[e]	0.979	0.959	447.9	<0.000	-0.263	0.769	0.231
	with pop. growth r = 0.032	0.974	0.948	346.9	<0.000	-0.231	0.794	0.206
	with pop. growth r = 0.065	0.965	0.930	253.8	<0.000	-0.198	0.820	0.180
Ad. ♂♂	Telemetry[d]						0.253[d]	0.747[d]
	Raw ages Hunter-kill	0.997	0.994	680.1	<0.000	-1.399	0.247	0.753
	Corrected for hunter selection[e]	0.997	0.995	758.7	<0.000	-1.389	0.249	0.751
	with pop. growth r = 0.032	0.997	0.995	734.4	<0.000	-1.357	0.258	0.742
	with pop. growth r = 0.065	0.997	0.994	700.9	<0.000	-1.324	0.266	0.734

[a] β = slope of regression line.

[b] S = survival rate = e^{β}.

[c] M = mortality rate = 1-S.

[d] survival and mortality rates determined by radio-telemetry during 1989-1996.

[e] See Tables 6.5 and 6.6 for females and Table 6.15 for males.

Table 7.9. Survival and mortality rates of adult female elk calculated from regressions of log of numbers in each cohort against age.

Cohort[a]	R	R^2	F	*P*	β[b]	S[c]	M[d]
1983	0.997	0.995	2296.8	<0.000	-0.228	0.796	0.204
1984	0.988	0.976	457.0	<0.000	-0.289	0.749	0.251
1985	0.993	0.986	723.1	<0.000	-0.235	0.790	0.210
1986	0.999	0.998	5328.7	<0.000	-0.241	0.786	0.214
1987	0.998	0.997	2408.3	<0.000	-0.249	0.780	0.220
1988	0.995	0.990	700.5	<0.000	-0.259	0.772	0.228
1989	0.996	0.992	756.7	<0.000	-0.221	0.802	0.198
1990	0.998	0.997	1488.5	<0.000	-0.281	0.755	0.245
1991	0.995	0.990	387.9	<0.000	-0.290	0.749	0.251
1992	0.993	0.986	206.8	<0.000	-0.274	0.761	0.239
1993	0.978	0.956	43.5	0.022	-0.293	0.746	0.254
Mean						0.772	0.228

[a] Cohort year = elk born in June of listed year.

[b] β = slope of regression line.

[c] S = survival = e^{β}.

[d] M = mortality = 1-S.

Adult Males

Bull elk in the Gravelly-Snowcrest Mountains were harvested at high rates, averaging about 75% annually. Unless bulls died from hunting wounds (wounding loss), were illegally killed, or dispersed to other states, hunters usually reported their deaths. The time when we lost contact with transmitter collars of bulls was not random (Table 7.11). We experienced greater than expected frequency of signal loss during August – November when hunting seasons were ongoing (Table 7.11). Greater than expected loss of signal during hunting seasons implied either illegal kill with the transmitter destroyed or removal of the transmitter with the elk to a distant location and non-report of the kill. Also, greater than expected frequency of loss of signal occurred during June and July (Table 7.11). These differences in observed versus expected frequencies were significant for 2- and 3-year-old bulls (χ^2_2 = 13.28 and 13.18, respectively, both $P < 0.001$). Yearling bulls exhibited similar tendencies, but differences were not significant (χ^2_2 = 4.7, $P = 0.09$). Higher than expected loss of signal during June and July, especially for 2-year-old bulls, implied dispersal beyond the search area (emigration). Knowledge of probable fates of these bulls whose transmitters had ceased to function allowed us to include them as part of the sample for some purposes.

Table 7.10. Estimated annual and mean mortality rate for adult female elk based on modeled population numbers, harvest from the SWHQ, wounding loss and natural mortality, Gravelly-Snowcrest Mountains, 1988-1996.

	A +	B =	C	D	D/C	E	D+E/C	F	D+E+F/C
Year[a]	Number Cows	Spring Female Calves[b]	Pre-hunt Cows ≥1 year	Corrected SWHQ Cow Harvest[c]	% Harvest Mortality	Wounding Loss[d]	% Mortality Including Wounding	Natural Mortality[e]	Total Mortality No. (%)
1988	4497	1090	5587	837	15.0	184	18.3	59	1080(19.3)
1989	4832	1088	5920	641	10.8	141	13.2	45	827(14.0)
1990	4791	1150	5941	640	10.8	141	13.2	45	826(13.9)
1991	5459	1449	6908	1019	14.8	224	18.0	72	1315(19.0)
1992	5599	1343	6942	985	14.2	217	17.3	69	1271(18.3)
1993	5676	1305	6981	750	10.7	165	13.1	53	968(13.9)
1994	6018	1474	7492	1295	17.3	285	21.1	91	1671(22.3)
1995	5828	641	6469	794	12.3	175	15.0	56	1025(15.8)
1996	5449	600	6049	1213	20.1	267	24.5	86	1566(25.9)
Mean					14.0		17.1		(18.0)

[a] Year = Spring-Fall.

[b] ½ of spring calf numbers – added in as yearlings.

[c] SWHQ data corrected based on proportions recorded at check stations.

[d] Wounding loss = 0.22 x reported harvest, estimated from telemetry data.

[e] Natural mortality = 0.0705 x reported harvest, estimated from telemetry data.

Table 7.11. Percent distribution by time period and age of bull, for loss of signal or failed transmitter.

		Age		
Time	% of year (expected)	1 year old n=31	2 year old n=35	≥3 year old n=13
June-July	16.7	12.9	31.4	23.1
August-November	33.3	51.6	48.6	69.2
December-May	50.0	35.5	20.0	7.7

Only small samples of radiocollared yearling bulls were available during 1984-1989 when the hunting regulation only allowed taking branch-antlered bulls (BAB). As discussed earlier, we included information from neckbanded yearling bulls and those for which the transmitter had ceased functioning (censored). These data, although still a relatively small sample, indicated that annual survival for yearling bulls during 1984-1989 was in a range of 0.643-0.857 (0.143-0.357 mortality, Table 7.12). The adjusted (best) estimate was 0.723 survival / 0.277 mortality. Rate of illegal mortality of spike-antlered bulls was estimated to be 0.188 and legal harvest of BA yearlings was 0.071 (Table 7.12). Based on other evidence from hunter check stations and the SWHQ, the sample of marked elk may have underestimated both legal harvest and illegal harvest. If we subtract predator loss and legally branched yearling bulls from the sample, the best estimate for illegal mortality of spikes was 10.53/44 (23.9%). However, at least some of the reported legal mortality was actually illegal mortality. Spikes were shot within HDs where their harvest was not legal and reported on the SWHQ and at check stations as being shot in HDs where they were legal. We believe that the majority of marked yearling bull elk that were never accounted for were illegally harvested. The column "All Unk. Survived" in Table 7.12 is an unlikely scenario because with the high harvest rate for bulls, most bulls that survived were eventually reported as shot by hunters in future years. Based on branching rates, post-season classifications, and reported hunter kill, legal harvest of yearling bulls was likely higher than the rate observed for marked bulls (Table 7.12). If 25% of yearling bulls were legally branched, with a harvest rate of 75%, legal harvest would have averaged 19% annually. Additionally, spikes remained legal to harvest in HD 325 and portions of HD 327 through 1989, so legal harvest rate of yearling bulls would have been higher than 19%, perhaps 25% or more.

The estimated rate of illegal mortality of yearling bulls (18.8%) and spike bulls (23.9%) we observed during years of BAB regulations was intermediate to the 34.8% reported for the Elkhorn Mountains of Montana (DeSimone and Vore 1992) and the 11% reported for the Grand Mesa area of Colorado (Freddy 2000).

Table 7.12. Mortality rates and causes for yearling male elk under a BAB regulation, Gravelly-Snowcrest Mountains, 1984-1989.

				Total		
Mortality/ Survival	Transmitted Sample	NB and Censored Sample[a]	NB and Cens. Sample Adjusted[b]	All Unk. Illegal[c]	Adjusted[b]	All Unk. Survived[d]
Legal Harvest	1(0.05)[e]	3(0.083)	3(0.083)	4(0.071)	4(0.071)	4(0.071)
Illegal Harvest	2(0.10)	1(0.028)	8.53(0.237)	15(0.268)	10.53(0.188)	3(0.054)
Predation	1(0.05)	0	0	1(0.018)	1(0.018)	1(0.018)
Unknown	0	12(0.333)	0	0	0	0
Survived	16(0.80)	20(0.556)	24.47(0.680)	36(0.643)	40.47(0.723)	48(0.857)
Total	20	36	36	56	56	56

[a] Yearling males with only neckbands or with nonfunctioning radio-transmitter collars.

[b] Adjustment is made by multiplying survivors x 0.223 which gives wounding loss and unreported kill of 2-year-old bulls. This figure is added to yearlings that survived because they were not reported as surviving to 2 years old. The remaining unknowns were considered to be illegal harvest.

[c] Assumes all censored radiocollared males and neckbanded males with unknown fates were illegally shot.

[d] Assumes all censored radiocollared males and neckbanded males with unknown fates survived the hunting season.

[e] Number (proportion).

Larger samples of radiocollared yearling bull elk were available during 1990-1996 and we present data as annual samples and as a total sample for the period with brow-tined bull (BTB) hunting regulations (Table 7.13). Annual rates and causes of mortality were similar in each of the 6 years (Table 7.13). Illegal mortality was most important, averaging 13.8% (likely 14.4%, see Table 7.13) annually. We had no evidence to suggest that the rate of illegal mortality declined with time after implementation of the BTB regulation (Table 7.13). Freddy (2000) reported a similar level of illegal mortality (11%) for yearling bulls under a BTB season in Colorado.

Table 7.13. Mortality rate and cause of death for radio-transmitter collared yearling male Elk under the BTB regulation, Gravelly-Snowcrest Mountains, 1990-1996.

Year[a]	*n* Sample Size	Total Mortality	Known and Probable Illegal Mortality	Legal harvest Idaho	Unknown Cause
1990-91	37	8(0.216)[b]	6(0.162)[b]	2(0.054)	0
1991-92	31	4(0.129)	3(0.097)	0	1(0.032)[c]
1992-93	31	4(0.129)	4(0.129)	0	0
1993-94	27	4(0.148)	4(0.148)	0	0
1994-95	31	5(0.163)	5(0.163)	0	0
1995-96	24	3(0.125)	3(0.125)[d]	0	0
Total	181	28(0.155)	25(0.138)[e]	2(0.011)	1(0.006)

[a] 1 June – 31 May

[b] Number(proportion)

[c] Probable delayed wounding loss, thus would be illegal kill

[d] Includes one probable illegal kill in Idaho

[e] If the probable delayed wounding loss is included as illegal kill, annual average loss to illegal kill would be 0.144.

Because of the small sample of radiocollared yearling bulls during 1984-1989, it is difficult to be certain of the mortality rate and rate of illegal kill. We believe the illegal mortality rate during this period ranged between 0.188 and 0.268, with a midpoint of 0.228 (Table 7.12). For 1990-1996, the illegal kill rate for yearling bulls was 0.144, which indicated that illegal mortality of yearling bulls was 36.8% lower under BTB regulations than BAB regulations. Expressed another way, illegal mortality was 58.3% higher under BAB than BTB regulations.

This difference in rates was not significant when the adjusted estimate was used for 1984-1989 data ($\chi^2_1 = 1.69$, $P = 0.19$). Even if the sample size for 1984-1989 data was equal to that of 1990-1996, the difference would only be significant at $P = 0.075$. The difference in illegal mortality rates would be statistically significant only if all but one of the unknown category in 1984-1989 was illegal mortality. As discussed earlier, that is certainly possible.

Hunters made fewer reports of observations of illegally shot yearling bulls at check stations during years of BTB regulations than during years of BAB regulations (Table 7.14). Because check station attendants may not have been as diligent in asking about hunter observation of illegal/wounding loss in later years as in the early years, it was important to examine reported observations on a relative basis among sex/age classes. Thus, on an annual basis, absolute numbers of yearling bulls and adult females reported abandoned declined between 1988-1989 and 1990-1996 (Table 7.14). However, relative to each other, only the rate of reports of abandoned yearling bulls declined between the periods (Table 7.14). Compared to their proportion in the population, abandonment/wounding loss of legal bulls, adult females, and calves increased between periods. We believe that reports of illegal kills/abandonment would have been higher during 1984-1987 than 1988-1989 had this information been recorded then.

Of 26 radiocollared yearling bulls illegally killed during 1990-1995, only 2 resulted in Notices-to-Appear (NTA, citations) being issued, for a detection with citation issued rate of 0.077. During the same period, 38 NTAs were issued within the study area for illegally killed yearling bulls. Seven of these NTAs were issued at check stations and 31 in the field. Thirty-five (92%) were issued for animals removed from the field and 3 (8%) for abandoned animals. Of illegally killed radiocollared yearling bulls, 11(44%) were known removed from the field and 14 (56%) were known abandoned in the field. Obviously, hunters abandoning illegal kills in the field are much less likely to be detected and issued NTAs than those attempting to take the animal home.

Known antler configurations of illegally killed radiocollared yearling bulls and those NTAs where antler configuration was recorded indicated that 15 (62.5%) were spike-antlered (1x1) and 9 were branch-antlered yearling bulls during 1990-1995. Thus, for the majority, there should have been no confusion with brow-tined bulls. Based on antler size, location of the carcass, and other evidence in the field, a minimum of 2 (7.7%) of 26 illegally–killed radiocollared yearling bulls were likely mistaken for cow elk when shot. Of total NTAs issued during 1989-1995, 27 (51.9%) were issued to residents of Montana and 25 (48.1%) were issued to non-residents. Non-resident hunters averaged 29.6% of general elk hunters in Gravelly-Snowcrest HDs during 1986-1995, so were disproportionately ticketed. This may occur because non-residents were more likely to be unaware of regulation changes or local differences in regulations and hunting district boundaries. Also, residents observing "non-residents" illegally harvesting an elk may be more likely to report them than to report their fellow locals.

Table 7.14. Hunter reports at check stations of elk wounding loss/illegal kill, Gravelly-Snowcrest Mountains, 1988-1996.

Year	Yearling Bulls	Legal Bulls	Adult Females	Calves
1988[a]	**82**	**6**	**27**	**5**
1989[a]	**41**	**2**	**36**	**3**
1990[b]	28	4	38	3
1991[b]	18	2	19	1
1992[b]	26	2	11	1
1993[b]	21	8	15	6
1994[b]	38	6	16	8
1995[b]	24	5	14	1
1996[b]	12	5	11	2
Total	290	40	187	30
1988-89(reports)	**123(60.9)[c]**	**8(4.0)**	**63(31.2)**	**8(4.0)**
1988-89(pop.)	**(9.0)[d]**	**(5.6)**	**(58.1)**	**(27.3)**
1990-96(reports)	167(48.4)[c]	32(9.3)	124(35.9)	22(6.4)
1990-96(pop.)	(9.7)[d]	(7.0)	(57.3)	(26.0)

[a] Branch-antlered Bull season.

[b] Brow-tined Bull season.

[c] number(%).

[d] (%) of elk population.

We can use the above information to estimate total illegal mortality of yearling bulls in the Gravelly-Snowcrest complex, and also to estimate total yearling bulls in the pre-season population. Total NTAs issued during 1990-1995 (38) divided by the detection/citation rate (0.077, for radiocollared bulls) equals 494, the point estimate for total illegal bulls during these 6 years (82/year). With small samples, a random difference in the detection rate could greatly influence the estimate. One more detection would provide an estimate of 329 (55/year) and 1 fewer would provide an estimate of 987 (165/year) illegal yearling bulls. Similarly, these estimates are minimal because some NTAs may have been written as "illegal possession" or "violation of Commission rules and regulations" and a "spike" bull was not noted on the NTA. Also, we may have overlooked one or more NTAs in the files. If we missed one violation per year, the low, point, and high estimates for illegally-killed yearling bulls would be 381 (64/year), 572 (95/year), and 1143 (191/year), respectively. The mean of all these estimates is 651 (109/year). The average of 82/year divided by the average illegal mortality rate for transmitter-collared yearling bulls yields a pre-season estimate of 582 total yearling bulls. An average of 109/year divided by the same rate results in a pre-season estimate of 773 total yearling bulls. This later figure seems closer to "true" numbers based on harvest and population estimates but may also be low. Estimates of total number of yearling males in the preseason population based on trend counts and modeling averaged 1,227 yearling bulls during the period. At a 14% illegal mortality rate, this would equal an average of 172 illegal yearling bulls/year, slightly below the highest estimate of 191/year calculated above. If a ratio of 75 males:100 females was the most accurate for yearlings, trend counts and modeling estimated an average of 1,052 yearling males in the preseason population. At a 14% illegal mortality rate, this equals an average of 147 illegally killed yearling bulls per year for the Gravelly-Snowcrest elk population during years of BTB regulations.

Few bulls ≥2 years old were equipped with transmitter collars during 1984-1989. We combined these bulls for a composite sample of annual mortality for the period. A total of 27 deaths during 36 elk years during this period represented a mortality/survival rate of 0.75/0.25. Twenty (74.1%) were harvested on the study area during the general season, 2 (7.4%) were wounding losses, 1 was harvested during archery season, and 1 was harvested in HD 360, east of the study area. Three (11.1%) were harvested in Idaho (1 not reported).

Combined mortality of transmitter-collared bulls ≥2 years old averaged 0.747 annually during 1990-1991 through 1997-1998 (Table 7.15), similar to the 1984-1989 period. During 1991-1992 through 1996-1997, when larger samples were maintained, annual mortality averaged 0.769 and ranged from 0.542 to 0.926 (Table 7.15). For this period, 95% confidence intervals (White and Garrott 1990) ranged from ± 0.021 in 1991-1992 to ± 0.043 in 1993-1994. All recorded mortality was due to hunting-related causes.

Table 7.15. Annual mortality rate for transmitter-collared bulls ≥2 years old in the Gravelly-Snowcrest Mountains, 1990-1991 through 1997-1998.

Year	n	Total Mortality	Hunting-related Mortality
1990-91	4	1 (0.250)[a]	1 (0.250)
1991-92	27	25 (0.926)	25 (0.926)
1992-93	23	19 (0.826)	19 (0.826)
1993-94	24	13 (0.542)	13 (0.542)
1994-95	27	21 (0.778)	21 (0.778)
1995-96	19	16 (0.842)	16 (0.842)
1996-97	23	16 (0.696)	16 (0.696)
1997-98	7	4 (0.571)	4 (0.571)
Total	154	115 (0.747)	115 (0.747)

[a] Number (proportion).

Data reported earlier (Table 7.8) for mortality rate of bulls ≥2 years old as determined by life table analysis indicated mortality rates ranging from 0.734 to 0.753, very comparable to the 0.747 rate determined by telemetry.

Although use of bulls with non-functioning radiocollars and those with only neckbands would underestimate wounding and natural loss, they can be included to estimate geographic distribution of kill. Including this data, 91.2% of bulls ≥2 years old died in

Montana, 5.5% died in Idaho, and 3.3% died in Wyoming (Table 7.16). For radiocollared bulls, 91.5% of deaths were due to rifle hunting and 8.5% due to archery. Wounding loss for the general season was 9.3% of all retrieved kill and 10.0% of retrieved and reported kill. For archery season, wounding loss was 50.0% of retrieved kill. These data indicated that to estimate wounding loss numbers for the area the reported legal harvest should be multiplied by 0.101. To estimate harvest loss of Gravelly-Snowcrest elk in other HDs and states, reported legal harvest should be multiplied by an additional 0.101. The one non-hunting death recorded was a bull with a non-functioning radiocollar that was struck by a vehicle in Idaho. After the reporting period, another bull with a non-functioning radiocollar was struck by a vehicle and killed near the same location. The illegal mortality was a bull that had been shot and field-dressed, but was left in the field. This could have been an overkill or someone who could not find their way back to the site (waste of meat).

Of marked bulls (includes BA yearlings during 1986-1989) killed in Montana during 1986-1997, 93 (62.4%) were killed by Montana residents and 56 (37.6%) were killed by non-residents. For data only through 1995 that are comparable to SWHQ data, non-residents killed 38.3% of 128 marked bulls while comprising 29.6% of general season hunters in Gravelly-Snowcrest HDs and 32.8% of general season hunter days. Data from the SWHQ during 1986-1995 indicated that non-residents killed 35.0% of bulls reported killed in the Gravelly-Snowcrest Mountains. Statewide, non-residents comprise about 17.3% of general season elk hunters and harvest 27.2% of bulls.

Table 7.16. Causes of mortality for bulls ≥2 years old in the Gravelly-Snowcrest Mountains, 1984-1998.

		Transmitter-collared Bulls			NB and Censored[a]	All
Cause of Mortality		1984-89	1990-98	Total	1984-98	Grand Total
Montana - Hunting	Gen.season –S.A.[b]	20(74.1)[c]	81(70.4)	101(71.1)	29(74.4)	130(71.8)
	Gen. Season-other	1(3.7)	2(1.7)	3(2.1)	2(5.1)	5(2.8)
	Shot –not reported	0	6(5.2)	6(4.2)	0	6(3.3)
	Wounding loss	0	9(7.8)	9(6.3)	2(5.1)	11(6.1)
	Archery season	1(3.7)	7(6.1)	8(5.6)	0	8(4.4)
	Archery wounding	2(7.4)	2(1.7)	4(2.8)	0	4(2.2)
	Illegal kill	0	1(0.9)	1(0.7)	0	1(0.6)
Montana - Total		**24(88.9)**	**108(93.9)**	**132(93.0)**	**33(84.6)**	**165(91.2)**
Idaho - Hunting	Gun seasons	2(7.4)	2(1.7)	4(2.8)	0	4(2.2)
	Wounding loss	0	2(1.7)	2(1.4)	0	2(1.1)
	Shot – not reported	1(3.7)	1(0.9)	2(1.4)	0	2(1.1)
	Archery	0	0	0	1	1(0.6)
Idaho – Other	Vehicle collision	0	0	0	1(2.6)	1(0.6)
Idaho - Total		**3(11.1)**	**5(4.4)**	**8(5.6)**	**2(5.1)**	**10(5.5)**
Wyoming - Hunting	Gun seasons	0	2(1.7)	2(1.4)	3(7.7)	5(2.8)
	Wounding loss	0	0	0	1(2.6)	1(0.6)
Wyoming - Total		**0**	**2(1.7)**	**2(1.4)**	**4(10.3)**	**6(3.3)**
Total		27	115	142	39	181

[a] Neckbanded bulls and transmitter-collared bulls for which contact was lost.

[b] General gun season – harvested on the Gravelly-Snowcrest study area (S.A.).

[c] Number (%).

Because of the high harvest rate and loss of transmitter function, we had only small samples of bulls older than 2 years. Although our data indicated a slightly higher mortality rate for 2-year-old bulls, differences in mortality rate by age among bulls ≥2 years old were not significant (Table 6.17, all $\chi^2_1 < 0.97$, all $P > 0.79$).

Table 7.17. Mortality rate by age for bull elk in the Gravelly-Snowcrest Mountains, 1984-1997 (yearling bulls 1990-1997 only).

	Transmitter-collared			Censored and neckbands			All	
Age	Total	Deaths	Survived	Total	Deaths[a]	Unk[b]	Total	Deaths[a]
1	181	28(0.155)[c]	153(0.845)	12	2.2(0.183)	4	193	30.2(0.157)
2	148	112(0.757)	36(0.243)	47	36.7(0.781)	17	195	148.7(0.763)
3	34	25(0.735)	9(0.265)	22	14.7(0.667)	10	56	39.7(0.709)
4	6	4(0.667)	2(0.333)	10	4.9(0.489)	6	16	8.9(0.556)
5	1	1(1.00)	0(0.000)	5	5(1.00)	0	6	6(1.00)
≥4	7	5(0.714)	2(0.286)	15	11.0(0.734)	6	22	16.0(0.727)

[a] Adjusted deaths, includes multiplying known deaths by 0.2234 to estimate wounding loss and unreported hunter kill.

[b] Non-adjusted (before adjusted estimate taken out).

[c] Number (rate).

During the 35-day general hunting season, the mean hunting season day of death for 2-year-old bulls (N=103) was the 10.52 day. For 3 year olds (N=23) and bulls ≥4 years old (N=10), mean hunting season day of death was 14.17 and 16.70, respectively. Older bulls tended to be shot later in the season, on average, but this difference was not significant (Kruskal-Wallis H (2, N = 136 = 3.90, $P = 0.14$), perhaps because of small sample size for older bulls.

Of marked bulls harvested during the study, 27.2% of 2-year-old bulls and 24.3% of all bulls were shot on the first day of the season each year (Table 7.18). During the first 8 days of the season each year (opening day through end of first full weekend) 56.3% of the harvest of 2-year-old bulls and 42.4% of the harvest of bulls ≥3 years old occurred (Table 7.18). The difference in harvest rate by age for the first 8 days of the season was not significant ($\chi^2_1 = 1.93$, $P = 0.16$). By the end of the first 3 weeks of the season, 83.5% of the harvest of 2 year olds and 66.7% of the harvest of bulls ≥3 years old had occurred. The difference in harvest rate at the end of the first 3 weeks of the season was significant ($\chi^2_1 = 4.33$, $P = 0.04$).

Table 7.18. Harvest of marked bull elk by time period and age, Gravelly-Snowcrest Mountains, 1984-1997.

		Age of Bull				All
Time Period	% of Season	2	3	≥4	≥3	Total
1st Day	2.8	28(27.2)[a]	3(13.0)	2(20.0)	5(15.2)	33(24.3)
Day 1-8	22.2	58(56.3)	11(47.8)	3(30.0)	14(42.4)	72(52.9)
Day 9-15	19.4	16(15.5)	3(13.0)	2(20.0)	5(15.2)	21(15.4)
Day16-22	19.4	12(11.7)	3(13.0)	0	3(9.1)	15(11.0)
Day 23-29	19.4	10(9.7)	2(8.7)	4(40.0)	6(18.2)	16(11.8)
Day 30-36	19.4	7(6.8)	4(17.4)	1(10.0)	5(15.2)	12(8.8)
Total	100	103	23	10	33	136

[a] Number (%).

Archery wounding loss.

CHAPTER 8

HUNTING REGULATIONS, HUNTER NUMBERS AND CHARACTERISTICS, AND ELK HARVEST

Regulations

Hunting regulations for elk in the Gravelly-Snowcrest Mountains area have been extremely varied since 1944 (Table 8.1) with relative stability occurring only during 1967-1980 and 1990-1999. In 1944, the regulation was, in effect, similar to the BTB regulation in place since 1990. The season was closed in 1945, 1946, and 1947. A BAB regulation was in effect in 1948, 1952, and 1953 in parts of the area, and 1965 for the entire area. Either-sex (ES) regulations were in effect for parts of the area and time periods during most of the 1950s, but an either-sex quota regulation occurred in 1956 and 1957. The study area was one large hunting unit until partitioned into smaller units in 1967. Hunting licenses were valid for any antlered bull (AB) during much of the 1960s and 1970s with additional either-sex permits issued. Recently, regulations have been either BAB or BTB with additional BTB/antlerless permits (Table 8.1).

Length and timing of the hunting season also varied considerably (Table 8.1). Seasons were as short as 2 day BAB with 1 day ES in 1953 and as long as 79 days ES for the portion of the area from Ruby Creek to Standard Creek in 1952. Very long ES seasons for this sub-area (included what is now the WCWMA) were in effect from 1951 to1954. This area contained private land with continual elk damage complaints despite only 30-100 elk using the area. Both quota seasons lasted 7 days. Twenty-day AB seasons followed by an additional 2 days of ES hunting occurred in 1959 to 1961. In 1962, a 3 days ES season was followed by 33 days of AB hunting. Thirty-six day seasons were common during the 1960s and 1970s, but 28- and 29-day seasons occurred in 1967 and 1968. In 1969-1971 and 1980, 43-day seasons were in effect. Thirty-six day seasons were in effect throughout the current study period. Generally, seasons ended by mid-November prior to 1962. Seasons extended through the Thanksgiving weekend after that with the exception of 1967.

Since 1968, either-sex permits were partitioned into split time periods in some HDs to reduce the possibility of opening day concentrations of hunters and late season concentrations of both hunters and elk on winter ranges. There was no special archery season in HD 324 during 1981-1987. For the BAB regulation, a legal branch was ≥1 inch during 1981 and 1982 and ≥4 inches thereafter (Table 8.1). During 1981-1989, some portions of the area were under BAB regulations and others under AB regulations. During 1991-1999, holders of antlerless permits were restricted to shooting only antlerless elk within the HD for which the permit was valid, but they could shoot bulls in other HDs. Prior to this, antlerless permit holders could shoot a bull in any HD under the provisions of their general elk license. Hunting license fees also changed over the years (Table 8.1), possibly affecting numbers of hunters afield.

Table 8.1. Elk hunting regulations for the Gravelly-Snowcrest Mountain area, 1944-1999.

Year	Elk Hunting Regulations	License Cost[a]
1944	"Brush-head bulls west of Gravelly Ridge Road"	Res. - $1.00 NR - $30.00
1945	CLOSED	
1946	CLOSED	
1947	CLOSED	Res. - $2.00
1948	Branch-antlered Bull (BAB) Nov. 16-Dec.31, Ruby Cr.-Standard Cr. only (46 days)	NR - $100.00
1949	As 1948 + So. Madison and Beaverhead counties (not including Centennial Mtns.) Either Sex (ES) Oct. 15 – Oct. 17 (3 days)	
1950	Same as 1949	
1951	ES, Oct. 15 – Nov. 15, Ruby Cr. – Standard Cr. only (32 days)	
1952	ES, Oct. 15- Jan. 31, Ruby Cr. – Standard Cr. (79 days) + BAB Beaverhead County	
1953	Nov. 1 & 2 - BAB and Nov. 3 – ES: Ruby Cr. – Standard Cr., Standard Cr. – Elk River, the Beaverhead county portions of current HDs 324 and 325. In addition, Ruby Cr. – Standard Cr. was open to ES elk hunting from Nov. 4 – Jan 31.	
1954	ES, Nov. 4 – Jan. 31, Ruby Cr. – Standard Cr. ES, Oct. 31 – Nov. 2, Standard Cr. – Elk River and all of the Snowcrest Mtns. W.of the Ruby River road + current HD 325	
1955	Antlered bull (AB) only Oct. 29 (noon) – Nov.6 (7 days) all of Gravelly-Snowcrest area. Also, 217 ES permits issued for the Blacktail area and 100 ES permits for the "Gravelly" area.	Res. - $3.00 + must hold $3.00 B & F
1956	Entire Gravelly-Snowcrest area open to ES elk hunting from Oct. 15 until desired quota was reached. Season was open 7 days, an estimated 996 elk were harvested.	
1957	As 1956, from Oct. 20. Season was open 7 days and an estimated 1,001 elk were harvested	
1958	Entire area (HD 33) – AB, Oct. 19 – Nov. 2 (15 days)	
1959	Entire area – AB Oct. 18 – Nov. 6 (20 days), ES Nov. 7 & 8	
1960	Entire area – AB Oct. 16 – Nov. 4 (20 days), ES Nov. 5 & 6	
1961	Entire area – AB Oct. 15 – Nov. 3 (20 days), ES Nov. 4 & 5	
1962	Entire area – ES Oct. 21-23, AB Oct. 24 – Nov. 25 (36 days)	
1963	Entire area – AB Oct. 20 – Nov. 24 (36 days)	
1964	Entire area – AB Oct.18 – Nov. 22 (36 days)	Res. - $1.00[b]
1965	Entire area – BAB Oct. 24 – Nov. 28 (36 days)	
1966	Entire area – AB Oct. 23 – Nov. 27 (36 days)	

Table 8.1. (continued.)

1967	Instead of 1 large hunting district (HD 33), the area was divided into 4 HDs: 322 (included current 330), 323, 324 (included current 327), and 325. All were AB, Oct. 22 – Nov. 19. Also, HD 323 had 50 ES permits and HD 324 had 75 ES permits. (29 days)	Res. - $3.00 NR - $125.00
1968	AB, Oct. 27 – Nov. 23. Also, ES permits were issued for 2 time periods, Oct. 27 – Nov. 9 and Nov. 10 – Nov. 23 as follows: HD 322 – 10, 10; HD 323 – 50, 50; HD 324 – 100, 100. (28 days)	NR - $150.00
1969	AB, Oct. 19 – Nov. 30 (43 days). HD 327 was created as a separate HD this year. ES/antlerless permits were also issued – these are listed elsewhere from here on.	
1970	AB + ES Permits, Oct. 18 – Nov. 29 (43 days)	
1971	AB + ES Permits, Oct. 17 – Nov. 28 (43 days)	
1972	AB + ES Permits, Oct. 22 – Nov. 26, current boundaries HD 323	
1973	AB + ES Permits, Oct. 21 – Nov. 25 (36 days)	
1974	AB + ES Permits, Oct. 20 – Nov. 24 (36 days)	
1975	AB + ES Permits, Oct. 19 – Nov. 23 (36 days)	
1976	AB + ES Permits, Oct. 24 – Nov. 28 (36 days)	Res. - $8.00 NR - $225.00
1977	AB + ES Permits, Oct. 23 – Nov. 27 (36 days)	
1978	AB + ES Permits, Oct. 22 – Nov. 26 (36 days)	
1979	AB + ES Permits, Oct. 21 – Nov. 25 (36 days)	
1980	AB + ES Permits, Oct. 19 – Nov. 30 (43 days)	
1981	HD 324 – **BAB**[c] + Permits – **No archery season**[d], Other HDs – AB + Permits, Oct. 25 – Nov. 29, BAB = a branch on 1 antler of ≥ **1 in.**	
1982	As 1981, Oct. 24 – Nov. 28 (36 days)	Res. – $9.00 NR - $275.00
1983	All HDs BAB[e] + Permits **except** HDs 325 & 327 AB + Permits, Oct. 25 – Nov. 27, BAB hereafter = a branch on 1 antler **≥4 in.**	Res. - $10.00
1984	As 1983, except current HD 330 split from HD 322, Oct. 21 – Nov. 25 (36 days)	NR - $300.00
1985	As 1984, Oct. 27 – Dec. 1 (36 days)	
1986	As 1985, Oct. 26 – Nov. 30 (36 days)	NR - $350.00
1987	As 1986, except all of area BAB except for HD 327 South of Centennial Road remains AB, Oct. 25 – Nov. 29 (36 days)	
1988	As 1987, Oct. 23 – Nov. 27 (36 days), **Archery season restored in HD 324**	NR - $450.00
1989	As 1988, Oct. 22 – Nov. 26 (36 days)	
1990	Entire area Brow-tined Bull **(BTB)**[f] + Permits, Oct. 21 – Nov. 25	

Table 8.1. (continued.)

1991	As 1990, except holders of antlerless permits restricted to shooting **only** antlerless elk in the HD for which their permit is valid, Oct. 27 – Dec. 1. (36 days from here through 1999)	
1992	As 1991, Oct. 25 – Nov. 29	Res. - $13.00 NR - $462.00
1993	As 1992, Oct. 24 – Nov. 28	
1994	As 1993, Oct. 23 – Nov.27	Res. - $16.00 NR - $475.00
1995	As 1994, Oct. 22 – Nov. 26	
1996	As 1995, Oct. 27 – Dec. 1	
1997	As 1996, Oct. 26 – Nov. 30	
1998	As 1997, Oct. 25 – Nov. 29	NR - $428/ $478.00[g]
1999	As 1998, Oct. 24 – Nov. 28	

[a] Res. = Resident hunter, NR = Non-resident hunter. Until 1964, resident licenses were big game combination licenses, since 1964, separate deer, and elk licenses were issued.

[b] Separate resident deer and elk licenses.

[c] Branch-antlered Bull = any branch on one antler of ≥1 inch in 1981 and 1982.

[d] For HD 324 only, there was no special archery season during 1981-1987.

[e] Branch-antlered Bull = any branch on one antler of ≥4 inches, 1983-1989.

[f] Brow-tined Bull = An elk with an antler(s) with a visible point on the lower half of either main beam that is ≥4 inches long.

[g] For 1998 and after, a license was available for elk, fishing and upland birds that did not include a deer license for $428.00. During 1996 and after, a quota of guaranteed outfitter-sponsored licenses were available at $835.00 or $735.00 without a deer license.

Hunter Numbers, Characteristics, and Opinions

Hunter Numbers

Either-sex hunting during the first 3 days of the season in 1962 compared to during the last 2 days in 1960-1961 possibly increased hunter numbers in the Gravelly-Snowcrest Mountains (Fig. 8.1). Hunter numbers dropped dramatically in 1963 (about 40%) after AB only hunting was implemented, reaching a low in 1965 (about 80% fewer hunters). This low coincided with a low in the deer population following the severe winter of 1964-1965 (Fig. 8.2). Elk hunter numbers then increased through 1970 in the Gravelly-Snowcrest Mountains despite increases in resident and non-resident license fees in 1967 and 1968 (Table 8.1). Statewide, however, elk hunter numbers stabilized after the fee increase (Fig. 8.2). A decline in total and resident hunter numbers in the Gravelly-Snowcrest Mountains between 1970 and 1973 (Fig. 8.1) may have been related to access restrictions associated with a road closure study in the Ruby drainage (Basile and Lonner 1979). A decline in elk hunter numbers both in the Gravelly-Snowcrest Mountains and statewide in 1976 (Figs. 8.1 and 8.2) coincided with a large license fee increase for both residents and non-residents (Table 8.1). Elk hunter numbers declined in the Gravelly-Snowcrest Mountains between 1979 and 1985, but increased statewide during the same period except for a dip in 1984.

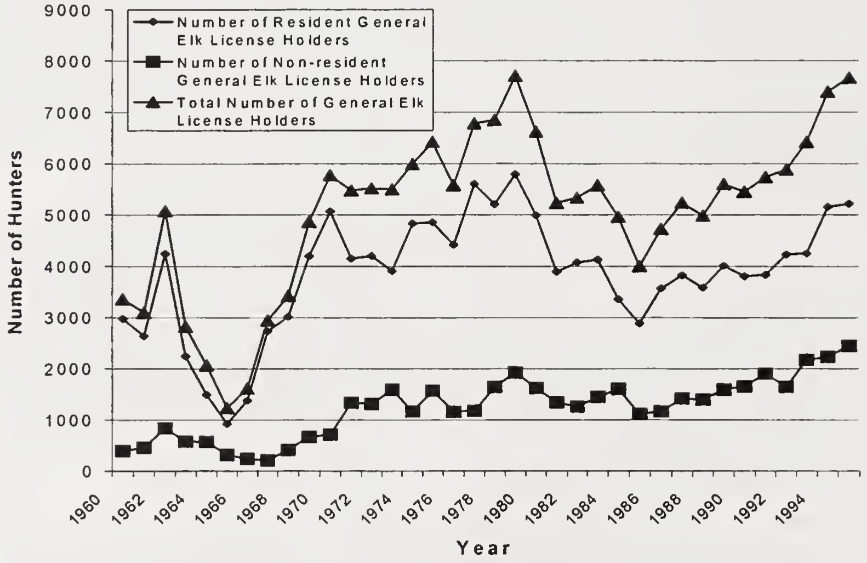


Figure 8.1. Number of elk hunters with a general elk license in the Gravelly-Snowcrest Mountains, 1960-1995.

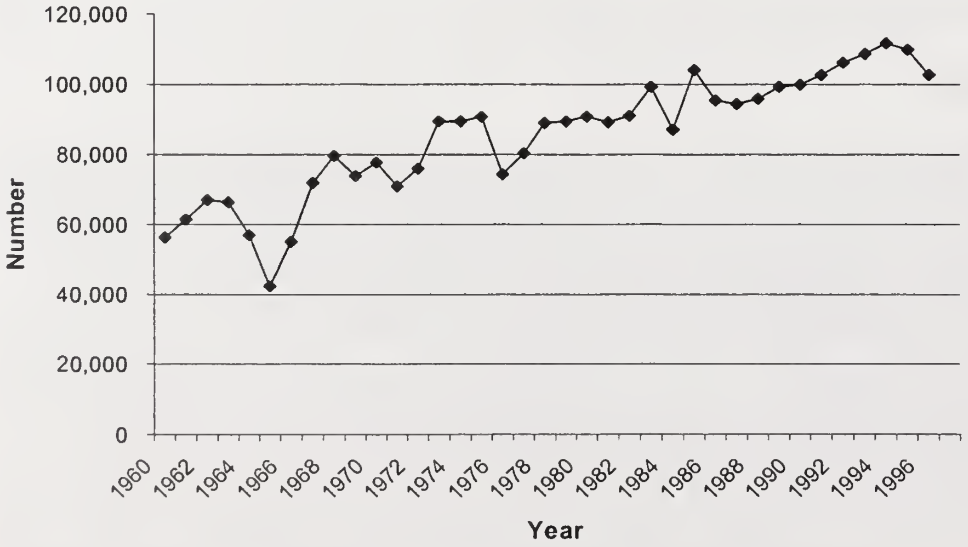


Figure 8.2. Number of elk hunters statewide, 1960-1996.

Declines in 1984-1985 may have been associated with a temporary decline in mule deer numbers in the state at this time. The substantial decline in the Gravelly-Snowcrest Mountains, however, was associated with very low bull:100 cow ratios (Chrest and Herbert 1980 and 1981) and implementation of BAB regulations (Table 8.1, Fig. 8.1). The decline was most pronounced (50%) for resident hunters who likely switched to adjacent hunting districts during this period. However, non-resident hunter numbers declined by 42% from peak levels in 1979, but recovered to 127% of the 1979 level by 1996. The almost 50% decline in total hunter numbers in the early 1980s was not enough to reduce the harvest rate of legal bulls. Thus, reductions of hunter numbers of more than 50% would be necessary to reduce bull harvest mortality (increase survival) in the Gravelly-Snowcrest Mountains. From 1985-1995, elk hunter numbers in the Gravelly-Snowcrest Mountains increased steadily. Statewide, they increased at a slower rate, declining in 1995 and 1996 (Fig. 8.2). Number of general elk license holders hunting in the Gravelly-Snowcrest Mountains during 1995 was near the peak of the late 1970s (Fig. 8.1).

Resident hunter days on the general elk license declined between 1978 and 1985, and then gradually increased to near the 1978 level by 1995 (Fig. 8.3). Total resident hunter days have been on an increasing trend since 1982, primarily because of increasing antlerless/ES permits issued (Fig.8.3). Although non-resident hunter days declined in 1980 and 1981 (Fig. 8.4), they did not go through a sustained decline. Non-residents hunter days were at an all time high in 1995. Because non-residents were limited to 10% of special permits, this increase was primarily a result of more non-residents hunting in Gravelly-Snowcrest HDs on the general license. The decline in numbers of hunters and hunter days in the 1980s associated with BAB regulations was greater for resident than non-resident hunters.

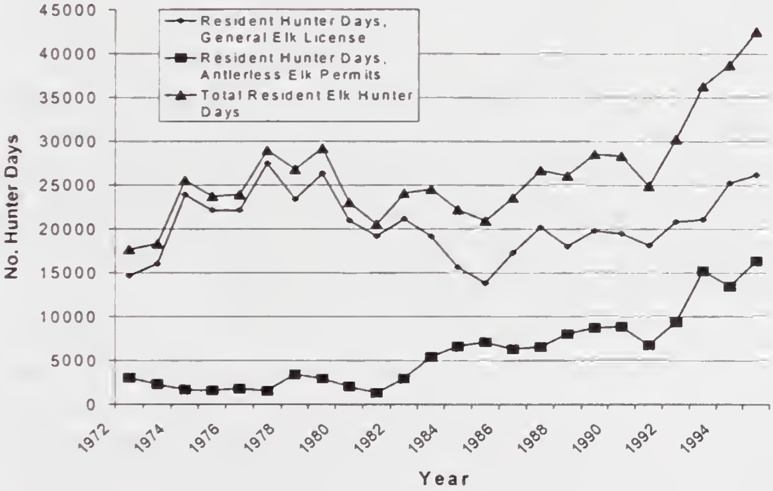


Figure 8.3. Number of resident hunter days, Gravelly-Snowcrest hunting districts, 1972-1995.

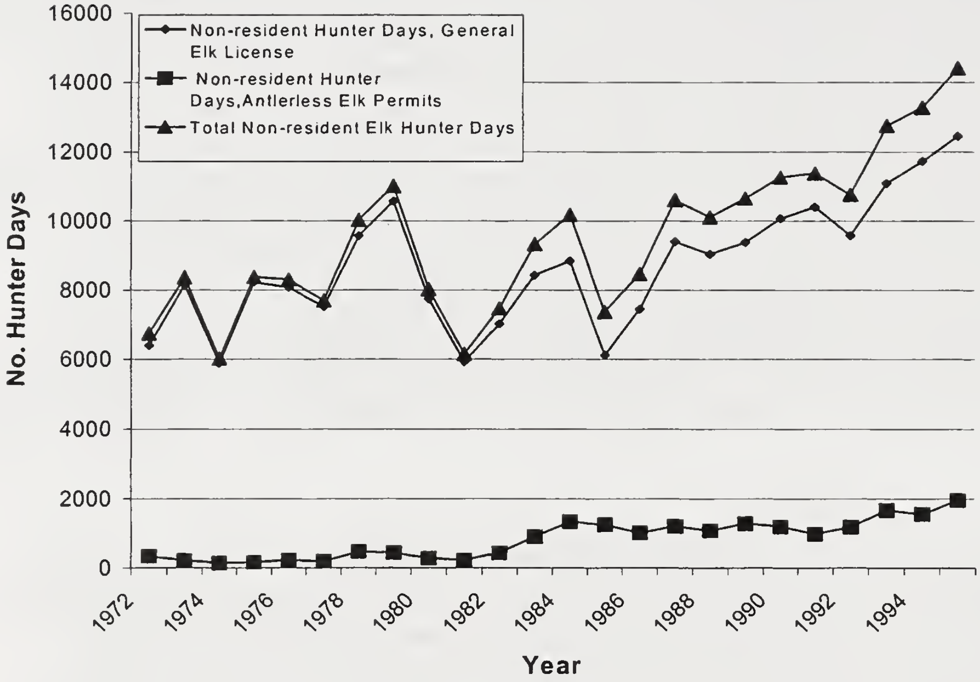


Figure 8.4. Number of non-resident hunter days, Gravelly-Snowcrest hunting districts, 1972-1995.

Although the percent of total hunters (including antlerless hunters) that was non-residents was relatively stable during 1972-1995, the percent of total bull elk killed by non-residents increased during the same period (Fig. 8.5). This likely occurred because of the increasing numbers of non-resident hunters and hunter days on the general license compared to residents (Figs. 8.1-8.4). A sharp increase occurred in 1996 because resident hunters declined while non-resident hunters continued to increase. The large decline in resident hunters in Gravelly-Snowcrest HDs in 1981, coinciding with the change to BAB regulations, was matched by a corresponding large increase in resident hunters in nearby HDs 331 and 332, which remained open to hunting any bull. This one-year increase in HDs 331 and 332 did not follow through in subsequent years, however.

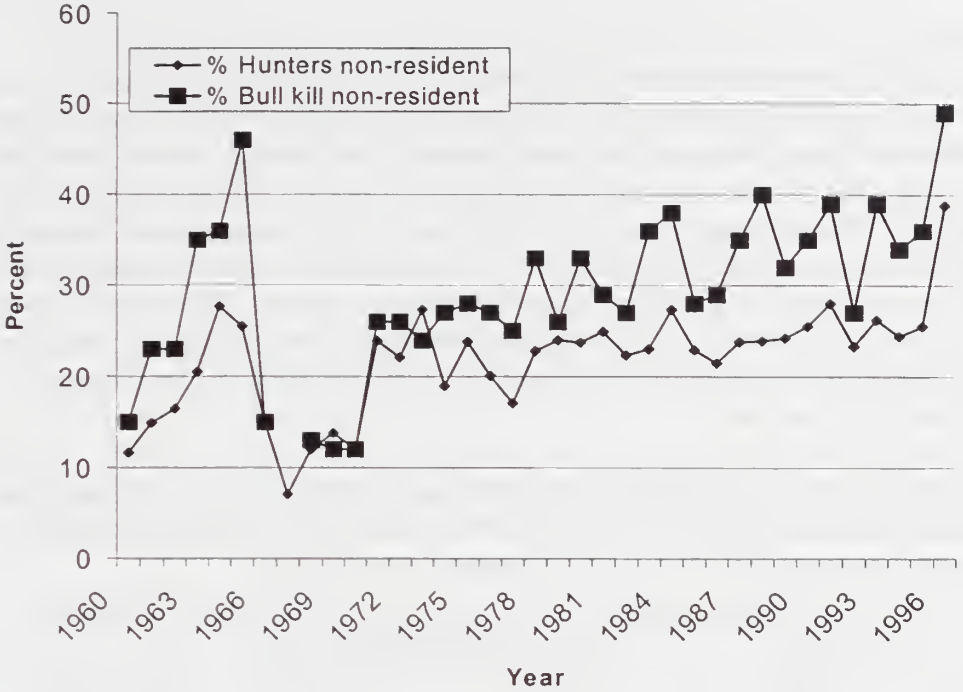


Figure 8.5. Percent of hunters that were non-resident and percent of bull elk harvest by non-resident hunters in the Gravelly-Snowcrest Mountains, 1960-1996.

Hunter Origin

We analyzed characteristics of 16,548 hunters interviewed at check stations during 1986, 1989, 1991, and 1996 to obtain 2-year samples during both BAB and BTB regulations. We did not detect a difference in hunter origin that we could unequivocally relate to a regulation change. We divided resident hunters into 4 major groups; those residing in Madison and Beaverhead counties (Local 1), those residing in Silver Bow, Gallatin, Deer Lodge, and Jefferson counties (Local 2), those residing in Missoula, Flathead, Ravalli, Lake, Sanders, and Lincoln counties (WOD), and all others (AO). There was an increase in WOD and AO hunters and a decrease in Local hunters during the period. During 1986, WOD hunters were 5.5% of the total compared to 15.4% in 1996. AO hunters were 17.5% of total hunters in 1986 compared to 21.3% in 1996. Local 1 hunters declined from 39.2% to 30.9% and Local 2 hunters from 37.7% to 32.5% from 1986 to 1996, respectively. Much of the decline in local hunters was the result of a decline in Beaverhead county hunters. That decline may have been related to sampling differences or Beaverhead county hunters increasingly hunting in nearby areas with AB regulations. During the latter years, check stations shut down ½ - 1 hour earlier than in 1986. Local hunters would be under sampled by an earlier check station closing because they could leave the hunting area later, having less distance to travel. In any case, WOD hunters increased in absolute as well as relative numbers. This indicated a real increase in hunters from Missoula, Flathead, Ravalli, Lake, Sanders, and Lincoln counties on the study area over the study period.

Resident hunter origin combined for all 3 check stations for the 4 years (Table 8.2) indicated that most hunters in the Gravelly-Snowcrest Mountains were from the following counties, in decreasing order: Beaverhead, Silver Bow, Gallatin, Madison, and Yellowstone. Overall, "local" hunters comprised about 2/3 of resident hunters. Hunters were recorded from all Montana counties except Daniels and Prairie, which likely would have been included if data from all years were examined. Hunters distributed themselves differently based on their origin (Tables 8.2 and 8.3). Although there were exceptions, hunters tended to hunt portions of the area closest to their origin. WOD hunters were most commonly recorded at the Blacktail check station and eastern Montana hunters were most commonly recorded at the Ennis check station. The upper Ruby River drainage was relatively popular with everyone.

Table 8.2. Percent distribution of Montana resident hunter origin by county for the Ennis, Ruby, and Blacktail check stations, 1986, 1989, 1991, and 1996, combined. Counties listed were the residences of 15,775 of 16,548 hunters interviewed.

County[a]	Check Station[b]			
	Ennis[c]	Ruby	Blacktail	Total
Beaverhead	0.2	3.0	53.4	23.9
Silver Bow	1.0	35.1	14.9	19.7
Gallatin	43.3	12.4	1.8	14.0
Madison	21.6	17.3	1.1	11.3
Yellowstone	16.5	10.7	1.3	7.9
Missoula	0.7	3.3	4.1	3.1
Flathead	0.8	1.3	4.7	2.7
Ravalli	0.6	0.7	5.2	2.6
Lewis & Clark	2.4	3.0	2.2	2.5
Jefferson	0.6	2.5	1.9	1.9
Deer Lodge	0.3	1.7	1.3	1.2
Cascade	0.8	1.6	0.8	1.1
Lake	0.4	0.6	1.7	1.0
Stillwater	1.7	1.4	0.1	0.9
Fallon	1.7	0.1	0.6	0.6
Big Horn	1.5	0.2	0.5	0.6
Carbon	1.1	0.5	0.1	0.5
No. of hunters	3,115	5,919	6,741	15,775

[a] Counties included if they comprised at least 1% of hunters at one check station.

[b] Data recorded as percent for each check station total. Total column is percent of combined hunter data, not average of stations.

[c] Hunter data for Ennis station is for Gravelly-Snowcrest hunters only.

Non-resident hunters comprised only 9.6% of hunters interviewed at check stations compared to about 25% of hunters recorded on the statewide hunter questionnaire. This likely occurred because of the greater frequency of day-hunting trips by resident hunters. We recorded hunters from 39 states other than Montana and 2 foreign countries during the 4 years for which we summarized data. California residents were 26.6% of non-resident hunters, Washington residents 16.5%, and Minnesota residents 10.3%. The remainder of the top 10 states in decreasing order included Pennsylvania, Wisconsin, North Dakota, Nevada, Oregon, Michigan, and Utah.

Table 8.3. Percent distribution of Montana resident hunters by check station (Ennis, Ruby, and Blacktail) for each county of origin, 1986, 1989, 1991, and 1996, combined. Counties listed were the residences of 15,775 of 16,548 hunters interviewed.

County[a]	Check Station			
	No. of Hunters	Ennis[b]	Ruby	Blacktail
Beaverhead	3,957	0.1	4.7	**95.2**
Silver Bow	3,260	1.0	**66.8**	32.2
Gallatin	2,312	**61.4**	33.3	5.4
Madison	1,861	38.2	**57.6**	4.3
Yellowstone	1,299	41.6	**51.3**	7.2
Missoula	515	4.5	40.0	**55.5**
Flathead	438	6.2	18.0	**75.8**
Ravalli	430	4.4	10.7	**84.9**
Lewis & Clark	421	18.3	**44.9**	36.8
Jefferson	312	6.4	**50.6**	43.0
Deer Lodge	204	4.4	**52.0**	43.6
Cascade	180	13.9	**53.9**	32.2
Lake	169	7.1	20.7	**72.2**
Stillwater	147	38.1	**57.8**	4.1
Fallon	103	**53.4**	6.8	39.8
Big Horn	96	**51.0**	14.6	34.4
Carbon	71	**49.3**	39.4	11.3

[a] County totals = 100%.

[b] Data for Ennis station are for Gravelly-Snowcrest hunters only.

Hunter Opinion Surveys

In 1984, 3 years after a BAB regulation was first implemented, an opinion survey was sent to hunters who indicated at check stations that they would respond to the mailing (Lonner and Schladweiler 1986). Although hunters were randomly asked to participate, surveys were sent only to willing participants, which resulted in a non-random survey. This method may be more likely to sample cooperative people and also those who want to share strongly held views than would occur with a random sample. This same method was used to obtain samples for opinion surveys in 1989 (last year of BAB regulation) and 1994 (fourth year of BTB regulation).

In 1994, we mailed 422 questionnaires and 267 (266 usable) were returned for a response rate of 63.3%. Responses to questions that we asked in at least two of the three years indicated similar responses in 1984 and 1989, but changes were observed in 1994 (Table 8.4).

Composition of the hunter sample was similar for all three years (Table 8.4). Nonresidents comprised 12.8% of the sample in 1994 with Washington and California the predominant states. According to the Statewide Hunter questionnaire, nonresident hunters comprise about 25% of elk hunters in the Gravelly-Snowcrest Mountains; thus our survey under sampled nonresident hunters. Resident respondents were from 54 Montana towns throughout the state. The largest samples were from: Butte - 18.3%; Dillon - 14.1%; Billings - 9.9%; Bozeman - 6. 1%; and Ennis - 4.2%.

Years hunted ranged from 1 to 56 with about 75% having hunted for 7 years or more. Ten percent had never killed an elk, 36.1% had killed 1-4 elk during their lives, and 53.9% had killed more than 4 elk. Days hunted ranged from 1 to 35; 51.5% hunted 6 days or less. Sixty-four percent of the hunters had hunted in Gravelly-Snowcrest hunting units for 5 years or more and 83% had shot an elk there.

Fifty-seven percent of the sample had killed an elk in 1994 compared to 20% in 1984 and 37% in 1989. These were higher percentages of success than observed for the general hunter population; therefore, it is likely that successful hunters responded to this survey at higher rates than unsuccessful hunters.

In 1994, the following percentage of hunters spent at least some time hunting by use of: vehicle - 62%, vehicle with limited travel on foot - 17%, foot travel - 90%, horseback - 21%, trail bike - 0%, ATV - 10%, and snowmobile - 7%. The composite percent time by each method for all hunters in the sample was: vehicle - 17.3%, vehicle with limited travel on foot - 6.3%, foot travel - 61.8%, horseback - 12.2%, trail bike - 0%, ATV - 1.5%, and snowmobile - 0.8%. These data were almost identical to those for 1989.

Very few hunters in the samples paid for outfitter services. Payment for packing out elk or horse rental may have increased in 1994, however. Percentages in these categories would likely be higher if nonresidents had been sampled proportionately. However, fewer nonresident elk hunters use outfitter services in the Gravelly-Snowcrest Mountain area than other Montana areas.

The percentage of hunters that also hunted elk by archery in the Gravelly-Snowcrest Mountains (10-12%) was about the same each year (Table 8.4).

Table 8.4. Responses of hunters to survey questions about their hunting experience in the Gravelly-Snowcrest Mountains during 1984, 1989, and 1994.

	1984	1989	1994
Number of Respondents	280	249	266
% Males	97.7	97.5	97.0
% Non-residents	12.0	3.6	12.8
% that killed an elk	20.0	37.0	57.1
% that also archery hunted	10.0	12.0	11.3
Quality of hunt (1 = poor, 10 = excellent)	5.7	6.1	7.3
% paying for full outfitter services	0.7	0.0	0.4
% paying for drop camp services	1.0	0.0	0.4
% paying for packing elk out	1.0	0.0	4.3
% paying for horse rental	1.8	1.2	2.4
% thinking that during the last 5 years total elk in the population has:			
increased	22.2	29.3	37.4
been stable	52.6	49.5	53.9
decreased	25.1	21.2	8.7
As above, except total bulls:			
increased	23.7	20.9	37.8
been stable	37.7	43.6	48.4
decreased	38.7	35.5	13.8
As above, except total branch-antlered/brow-tined bulls:			
increased	21.3	19.6	40.1
been stable	34.8	37.4	40.5
decreased	44.0	42.9	19.4
% satisfied with opportunity to see a branch-antlered/brow-tined bull	58.6	48.1	74.2
% satisfied with killing an elk regardless of sex/age	48.3	54.1	57.9
% satisfied with existing regulations	70.0	64.5	81.0
% observing yearling bulls illegally or accidentally shot and left or shot and taken home	NA[a]	33.7	26.1
% reporting observation of yearling bulls taken home	NA	6.0	5.6
Numbers per hunter of reported yearling bulls:			
shot and left	NA	0.79	0.34
shot and taken home	NA	0.09	0.09

[a] NA = not asked or non-applicable.

One of the biggest changes among years of the survey was the increased perception by hunters that total elk, total bulls, and especially brow-tined bulls had increased in the last 5 years (Table 8.4). That perception accurately reflected what occurred in the elk population. The differences were all significant at $P < 0.05$ except for the perception of change in BAB between 1984 and 1989. The most dramatic change in hunter perception of elk numbers occurred between 1989 and 1994. Following 4 years of BTB regulations, hunters believed that total elk, total bulls, and BTB had increased in numbers. Differences were most apparent for hunters who had actually hunted in the Gravelly-Snowcrest Mountains for 5 years or more.

On a scale of 1 to 10 (1 = poor, 10 = excellent), hunters ranked the quality of their 1994 hunt an average of 7.3 compared to 6.1 in 1989 and 5.7 in 1984. Similar to prior years, successful hunters in 1994 ranked the quality of their hunt higher (8.0) than unsuccessful hunters (6.4). These numbers were higher in both categories than in the earlier years; even unsuccessful hunters in 1994 ranked the quality of their hunt higher (6.4) than did all hunters in 1989 (6.1) and 1984 (5.7). Thus, even accounting for increased numbers of successful hunters in 1994, an increase in reported quality of the hunt occurred.

In 1994, 74% of hunters were satisfied with the current opportunity to see brow-tined bulls compared with 59% in 1984 and 48% in 1989 (all differences significant at $P < 0.01$, Table 8.4). Eighty-one percent of hunters were satisfied with existing regulations in 1994 compared to 65% in 1989 and 70% in 1984 (all differences significant at $P \leq 0.01$). These opinions may reflect increased numbers of elk and a more positive perception of the brow-tined bull regulation than the branch-antlered bull regulation. The data also reflected increasing dissatisfaction with the BAB regulation from 1984 to 1989.

From 1989 to 1994 a 23% decline ($P = 0.003$) occurred in the percentage of hunters reporting having observed yearling bulls illegally or accidentally shot and left or shot and taken home (Table 8.4). The percentage reporting observations of yearling bulls illegally shot and taken home was about the same both years ($P = 0.27$, Table 8.4). The number of yearlings reported shot and left declined 57% ($P < 0.01$), but the observation rate of those reported shot and taken home did not decline ($P = 0.94$, Table 8.4). This indicated that the BTB regulation reduced accidental kill of yearling bulls as hoped, but intentional kill of yearlings was relatively unaffected (as expected). Yearling bulls comprised 54% of the 168 elk reported shot and left in the field in this survey and 53% of those reported at check stations.

Sixty-three percent of hunters responding to the questionnaire in 1994 also hunted deer in Gravelly-Snowcrest hunting districts. Thirty-one percent killed a deer. Eighty-five percent of the deer killed were mule deer; 64% were bucks and 36% were antlerless. Forty-three percent of the respondents did most of their deer hunting in Gravelly-Snowcrest hunting units. Sixty-eight percent of respondents mainly hunted the Gravelly-Snowcrest area for elk, only 1.6% mainly for deer, and 31% equally for both elk and deer. Seventy percent of respondents would not hunt deer in this area if they could not hunt elk there. If they were not allowed to hunt deer in this area, 96.5% of respondents would continue to hunt elk there.

We asked hunters an open-ended question soliciting any other opinions about elk management in the Gravelly-Snowcrest Mountains (Table 8.5). We list these responses in descending order of frequency for the 1984 survey and compare them with response rate for 1989 and 1994. Fewer people gave additional comments in 1989 and 1994 than in 1984 ($P < 0.01$).

Table 8.5. Summary of responses to the open-ended question about elk management in 1984, 1989, and 1994 hunter opinion surveys of Gravelly-Snowcrest hunters. Expressed as a percent of total questionnaires returned.

	1984	1989	1994
Total sample size	280	249	266
Did not comment	22.9	52.2	50.6
Expressed problems with ATVs/snowmobiles	16.1	4.4	8.2
Pleased with BAB regulation	15.7	0.8	NA[a]
Too many closed roads/need more access	11.4	3.6	5.2
Need more MFWP/USFS enforcement presence/higher fines	7.1	6.8	5.2
Limit non-resident hunters	6.4	4.4	2.6
Need more motorized game retrieval opportunities	6.4	2.8	6.0
Put all elk hunting, including bulls on drawing/limited entry	6.1	2.4	1.9
Problems with private land blocking access to public land	6.1	1.2	2.6
Issue more antlerless permits	5.0	1.2	0.8
Allow any bull to be shot	5.0	0.8	3.0
Close bull season for 1-5 years	4.3	0.8	0.8
Close more roads/trails	3.2	3.6	3.4
Pleased with MFWP management	2.9	4.4	8.2
Antlerless permit holder should not be allowed to shoot bulls	2.5	4.4	NA
Close/restrict archery hunting	2.1	1.6	1.5
Restrict horseback access	2.1	1.6	-
Problems with illegal/rude/etc. outfitters	1.4	2.4	1.1
Issue fewer antlerless permits	1.4	-	2.6
Institute a muzzleloader season	1.1	-	1.5
Stop split antlerless season	1.1	0.8	1.1
Reduce cattle grazing	0.7	3.6	1.9
Antlerless permit holders should be allowed to shoot bull	NA	NA	4.5
Fewer deer than in past	-	-	1.9

[a] NA = not applicable.

In all years, problems with off-road vehicle use, including requests for greater enforcement of existing regulations, was the number one issue of concern. However, requests for more motorized game retrieval opportunities and more open roads were also common (Table 8.5). Taken together, access and travel restriction issues were of greatest concern to hunters. As the elk population and hunter success increased, comments indicating satisfaction with MFWP management also increased (difference between 1984 and 1994 significant at $P = 0.006$).

Generally, the questionnaire results indicated support for and satisfaction with changes in elk management made by MFWP. This could change if elk populations and/or hunter success decline. The questionnaire also indicated that illegal kill of yearling bulls declined after implementation of the BTB season. Access, travel management, and ATV conflicts were the primary unresolved issues facing MFWP and USFS managers.

Elk Harvest Gravelly-Snowcrest Mountains

Statewide Harvest Questionnaire

Estimated harvest of antlerless elk was about 30-50% of bull harvest from 1968-1983 (Figs. 8.6 and 8.7, Appendix Table C1). After substantial increases in numbers of antlerless permits issued starting in 1984, antlerless harvest was about 1-1.5 times bull harvest. During 1978-1989, bull harvest was stable, averaging 694 annually, with small annual fluctuations despite an increasing elk population (Fig. 8.6). Average annual bull harvest increased to 960 during the period of BTB regulations in 1991-1996. There were wide annual fluctuations in bull harvest during this period, however, primarily due to weather conditions during the hunting season.

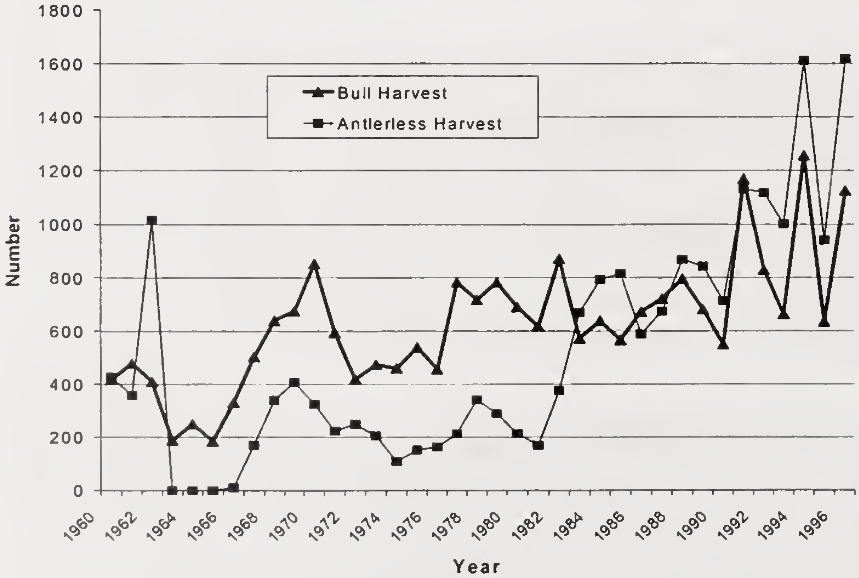


Figure 8.6. Bull and antlerless elk harvest estimated by the Statewide hunter questionnaire, Gravelly-Snowcrest Mountains, 1960-1996.

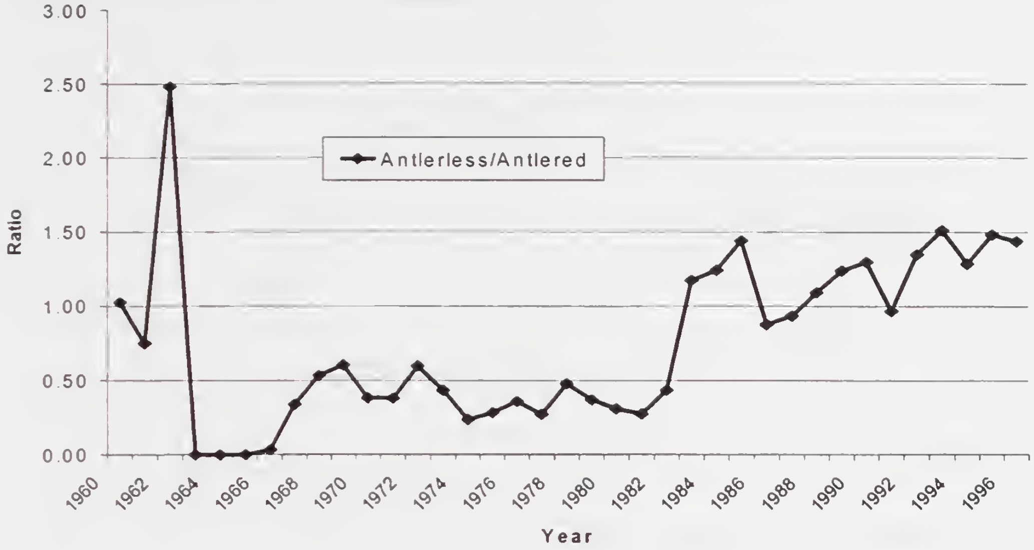


Figure 8.7. Ratio of antlerless to antlered elk in the harvest as estimated by the statewide hunter questionnaire, Gravelly-Snowcrest Mountains, 1960-1996.

Harvest of antlerless elk was about 2.5 times that of bull harvest during 1962 when the first 3 days of the season was for either-sex elk. Although portions of the area had different season types, antlerless harvest ranged from 1 to 2.5 times antlered harvest during 1949 through some of the 1950s, when portions of the area had ES regulations for 3 days. Starting with the issuing of limited antlerless/ES permits in 1967, antlerless harvest was much more predictably controlled relative to bull harvest. Antlerless elk harvest averaged about 1290 annually during 1993-1996 compared with an average of about 250 during 1968-1982. From 1983-1996, the antlerless/antlered ratio in the harvest averaged 1.24 (Fig. 8.7). From 1968-1983, the antlerless harvest closely tracked the number of hunters with antlerless permits (Fig. 8.8). After 1984, substantial increases in the number of antlerless permits issued resulted in a less close relationship between number of antlerless hunters and antlerless harvest (Fig. 8.8). This divergence was even greater after 1992, when antlerless permits were almost doubled from previous levels (Fig. 8.8).

Yearling bulls made up an increasing proportion of the bull harvest estimated by data provided by the statewide hunter questionnaire from 1968-1980 (Figs. 8.9 and 8.10). As Gravelly-Snowcrest hunting units converted to BAB regulations starting in 1981, the proportion of yearling bulls in the harvest declined as a function of the regulation change (Figs. 8.9 and 8.10). From a peak of about 76% of bull harvest in 1979-1980, yearling bulls declined to about 25% of bull harvest during the last 2 years of BAB regulations and 4.4% during BTB seasons in 1990-1996. Almost all harvest of yearling bulls during 1990-1996 was self-reported illegal kill; 61% was of 1 x 1 antlered bulls. Severe weather early in the hunting season that moved elk to near and on the winter ranges resulted in heavy harvests of bulls in 1991, 1994, and 1996. These heavier-than-usual harvests led to low harvests the following year, which were not as apparent for antlerless elk (Figs. 8.6 and 8.8).

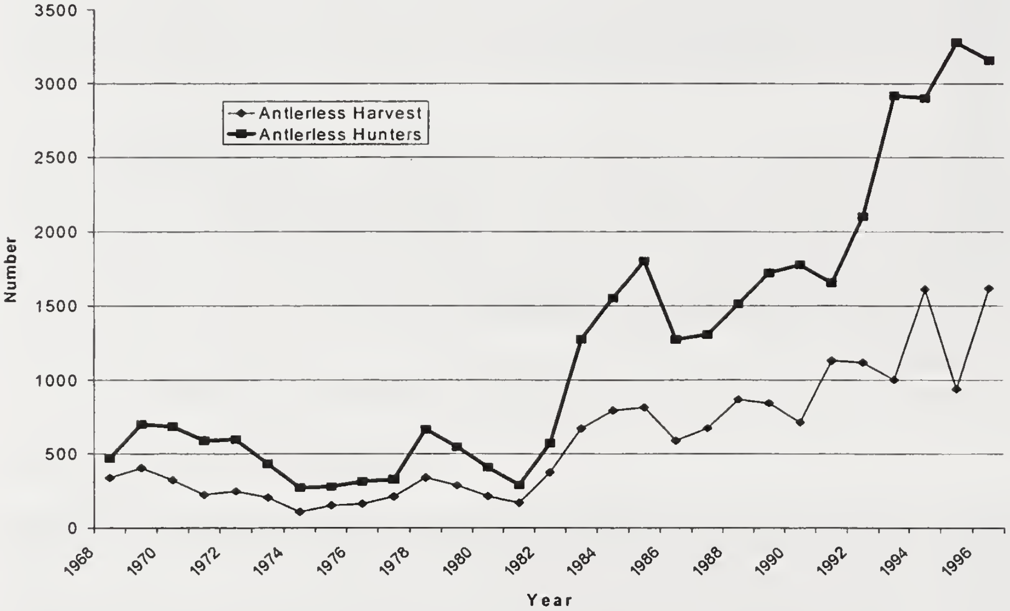


Figure 8.8. Antlerless elk hunters and harvest, Gravelly-Snowcrest Mountains, 1968-1996.

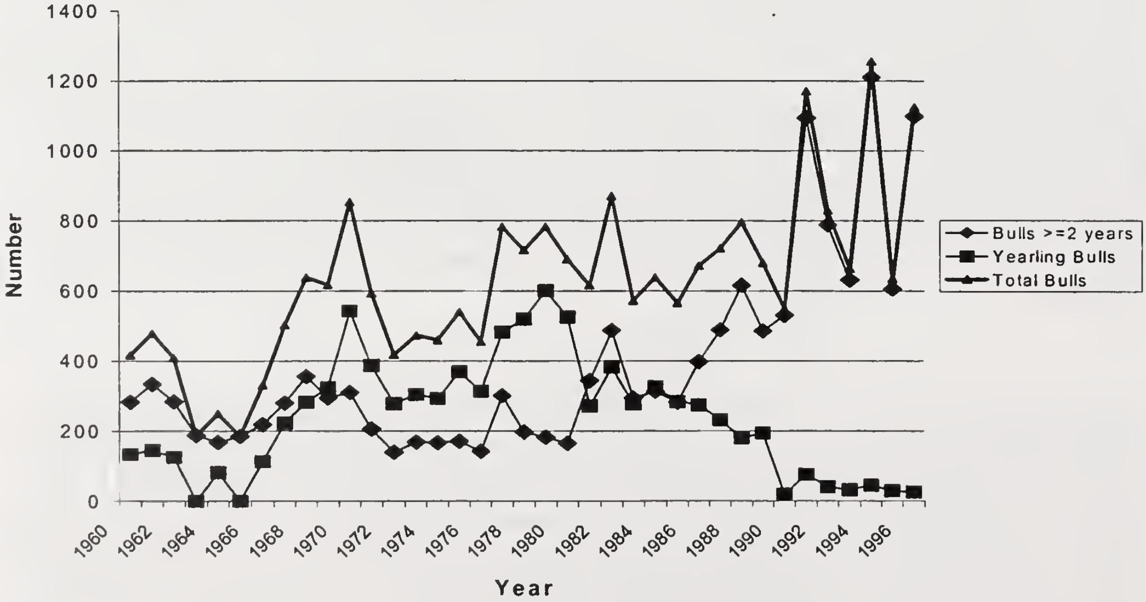


Figure 8.9. Bull elk harvest estimated by the statewide hunter questionnaire, Gravelly-Snowcrest Mountains, 1960-1996.

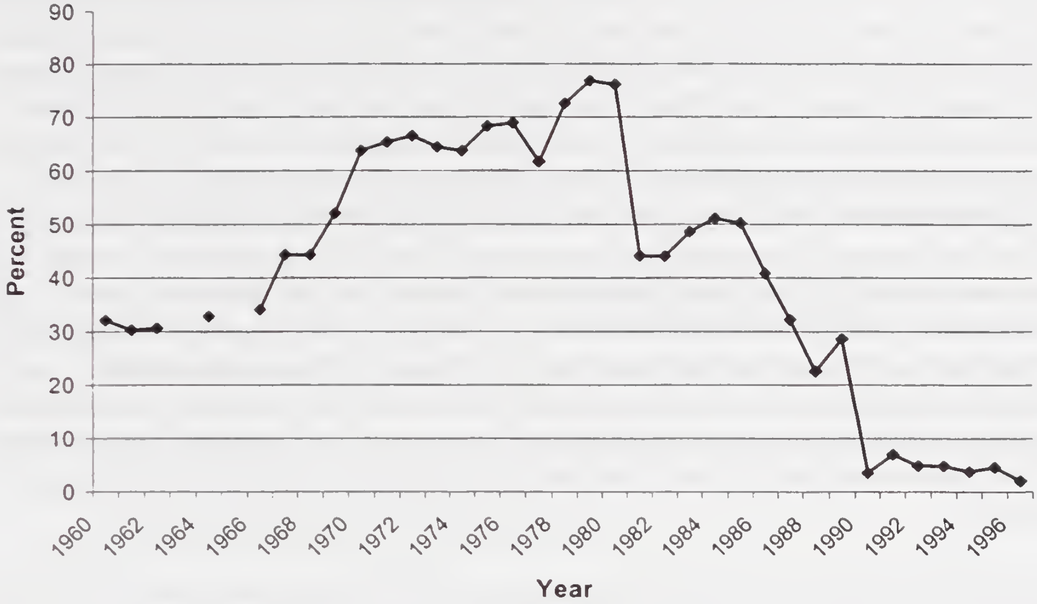


Figure 8.10. Percent of bull harvest in the Gravelly-Snowcrest Mountains comprised of yearlings, statewide hunter questionnaire, 1960-1996.

The percent of the annual harvest of bulls shot during the first week (8 days) of the general big game season has been used as an indicator of vulnerability to hunting by MFWP. We suspected that this percentage varied with habitat conditions such as percent hiding cover and amount of open roads or other expressions of hunter accessibility. We observed no consistent trend in this percentage over a 10-year period for the Gravelly-Snowcrest Mountain hunting districts (Table 8.6). The mean percent of bulls shot during the first 8 days was higher in HD 324 than in HDs 325 ($t = 3.83$, $P < 0.01$), 327 ($t = 3.12$, $P < 0.01$), and 330 ($t = 4.06$, $P < 0.01$). For HD 323, the mean percent of bulls shot the first 8 days was higher than in HD 325 ($t = 2.46$, $P = 0.02$) and HD 330 ($t = 2.52$, $P = 0.02$). Also, a higher ($t = 5.234$, $P < 0.01$) percent of bull kill by non-resident hunters was taken during the first 8 days of the season than for bull kill by residents (Table 8.6). The percent of bulls shot the first 8 days was not different between BAB and BTB seasons for total, resident, or non-resident hunters (t-tests, all $P \geq 0.42$). The overall average of 50% of bull kill occurring in the first 8 days of the season reported by hunters on the SWHQ (Table 8.6) was nearly identical to the 52.9% observed for marked bulls (Table 7.18).

These results indicated some problems with use of percent bulls shot during the first week to compare habitat conditions within smaller areas. Habitat conditions were most secure for elk in HD 323 compared to the other Gravelly-Snowcrest HDs yet the percent of bulls shot during the first 8 days was not lowest there (Table 8.6). A possible explanation was that the percent of general license hunters in HD 323 comprised of non-residents (38.1%) was higher than for other HDs; HD324 (24.9%), HD 325 (26.5%), HD 327 (35.3%), and HD 330 (31.4%). This would proportionately bias the percent bulls shot the first 8 days higher in HD 323 compared to the other HDs. Also, once elk experienced the first few days of hunting pressure in HD 323, they could move to more remote areas with greater cover than in other HDs. This reduced their risk of mortality later in the season. Harvests in HDs 325 and 327 were affected by variable weather influencing the timing of movements and availability of large migratory segments. Many of the elk typically harvested in HDs 325 and 327 were not in Montana and available for harvest during the first 8 days of the general hunting season. Harvest in the HDs with more outfitting such as HD 327 and HD 330 tend to be more spread out, reducing percent kill the first 8 days. It is also possible that there is not enough security in any of the Gravelly-Snowcrest HDs to affect harvest the first 8 days. A variety of these and other influencing factors must be considered in use of percent bull kill during the first week of the season as an indicator of habitat security conditions. However, percent bull kill during the first week of the season may function as a comparative indicator of habitat security on a statewide basis.

Table 8.6. Percent of season's total bulls reported shot during the first week (8 days) in Gravelly-Snowcrest hunting districts, SWHQ, 1982-1995.

Year	Hunting District						Category of Hunter	
	323	324	325	327	330	Total[a]	Resident	Non-resident
1982-85	62	60	32	42	40	48	42	60
1986	73	70	32	36	50	51	47	64
1987	65	70	50	33	60	56	55	56
1988	57	52	25	36	53	42	35	62
1989	54	47	29	45	44	45	40	58
1990	45	55	62	65	36	53	48	67
1991	50	58	49	65	22	48	43	56
1992	49	61	46	35	44	47	44	54
1993	62	83	58	52	52	64	61	67
1994	50	54	38	42	40	46	41	56
1995	37	68	52	61	43	54	51	58
Mean	55	62	43	47	44	50	46	60

[a] Total includes HDs 322 and 326.

During much of the 1980s and 1990s, antlerless permits in HDs 323 and 324 were split into 2 and 3 time periods, respectively. As the total number of permits increased, the intent was to not have all permits valid on opening day, which could potentially create an opening day "firing line". Similarly, it was not desirable to have all permits valid late in the season during years when severe weather forced elk to open winter range areas. During 1986-1995, HD 323 was split into a 22-day early period and a 14-day late period. Usually, about half the number of permits were issued for the late period as for the early period. For HD 324 there was an 8-day early period, a 19-day middle period and a 9-day late period. Permit numbers were highest in the middle period.

Little difference in average hunter participation or harvest rate occurred among time periods (Table 8.7). Harvest rate and hunter participation were more predictable during the early period (lower coefficient of variation) and more variable in the later periods (Table 8.7). In 1991 and 1994 when elk were on winter ranges during the hunting season, hunter success was high during the late periods. During hunting seasons when the weather was mild throughout the hunting season, success during the late period was lower than for other periods. The split seasons distributed hunting pressure but did not significantly affect participation or success rates. Reducing the number of antlerless hunters afield during the opening week did not reduce the percent of bull kill that occurred during the opening week. That percentage was higher in HDs 323 and 324, the HDs with split seasons, than in the other HDs where all permits were valid season long (Table 8.6).

Table 8.7. Hunter participation and success rates during split antlerless seasons in HDs 323 and 324, 1986-1995.

Hunting district and time period			% of permit holders that hunted[a]	Harvest per hunter[a]	Harvest per permit[a]
HD 323	Period 1	22 Days	84.7(5.9)	0.32(32.4)	0.27(34.3)
	Period 2	13 Days	81.5(11.4)	0.34(53.4)	0.28(52.0)
HD 324	Period 1	8 Days	92.2(3.6)	0.55(18.7)	0.50(18.6)
	Period 2	18 Days	87.1(3.1)	0.45(31.4)	0.39(30.5)
	Period 3	9 Days	88.1(5.9)	0.48(48.4)	0.42(48.2)

[a] Mean (CV), CV = coefficient of variation = SD/Mean.

At low levels of antlerless/ES permits, harvest tracked the number of permits issued (Figs. 8.11 – 8.15) However, the number of antlerless permits issued appeared to reach a saturation point in recent years beyond which increases in permits issued resulted in little additional harvest. This likely occurred for several reasons. Possibly, as the number of permits available increased, less serious or able hunters and family members may have received more of the permits. Also, after 10-12 years of increasing levels of antlerless permits, just harvesting an elk was not a new experience for most hunters. They may have been less likely to want to harvest antlerless elk far from roads. Because they had shot an elk in prior years, many hunters may have tried to harvest a bull through most of the season, holding their antlerless permit in reserve. When they finally tried to fill the antlerless permit, elk may not have been easily available.

Little additional antlerless harvest resulted in HD 323 when more than 400 antlerless permits were issued (Fig. 8.11). Similar “saturation levels” apparently occurred at about 800 permits in HD 324, 400 permits in HD 325, 500 permits in HD 327, and 400-500 permits in HD 330 (Figs. 8.12, 8.13, 8.14, and 8.15). In recent years, success rates for the antlerless permits were highest in HD 325, declining in the following order by hunting district: 325, 324, 327, 330, and 323. As for bulls, weather conditions during the hunting season appeared to be a major factor affecting antlerless harvest. Early severe weather during 1991, 1994, and 1996 resulted in high harvests of antlerless elk.

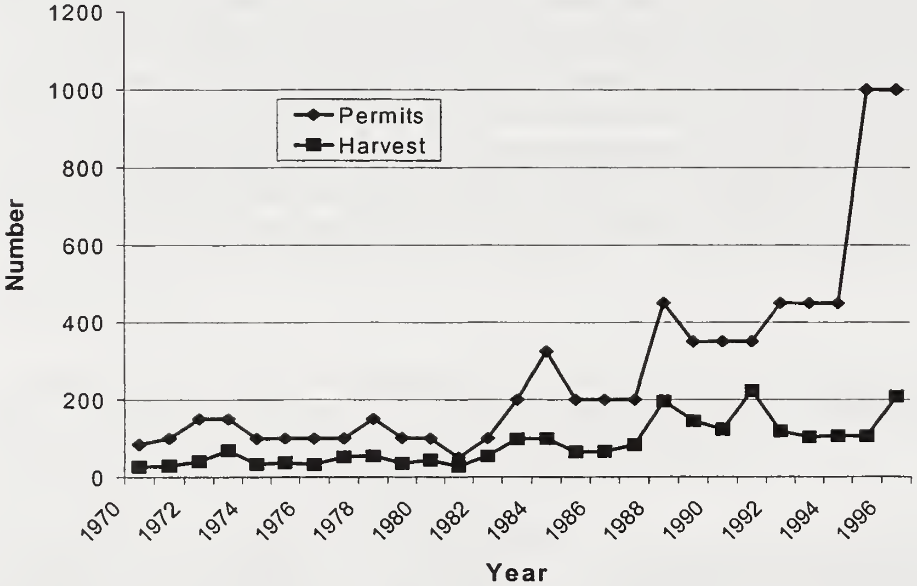


Figure 8.11. Antlerless permits issued and harvest in HD 323, 1970-1996.

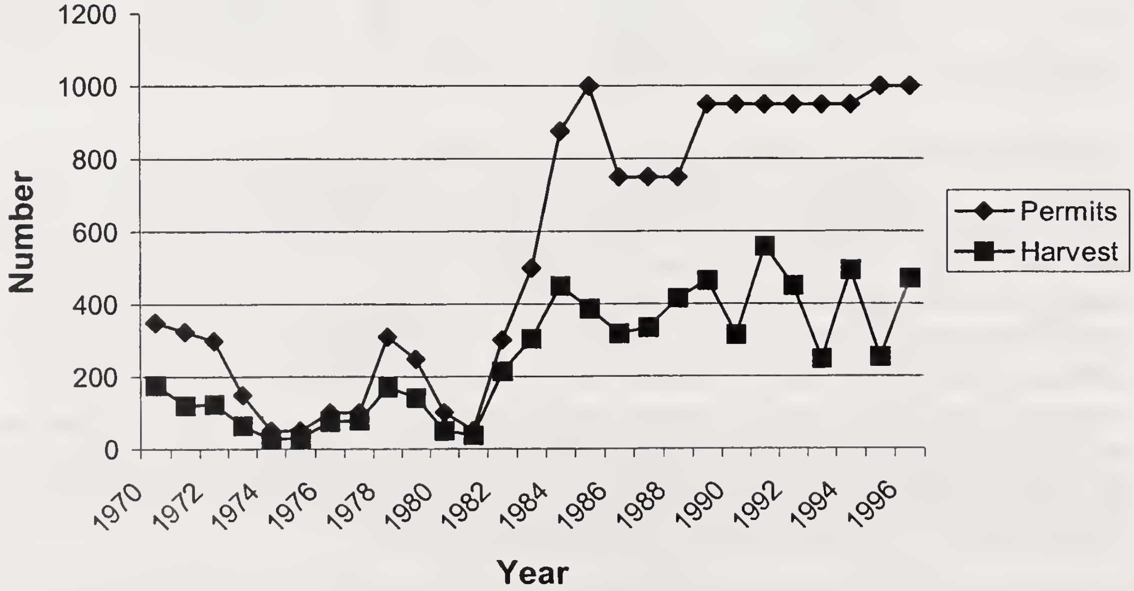


Figure 8.12. Antlerless permits issued and harvest in HD 324, 1970-1996.

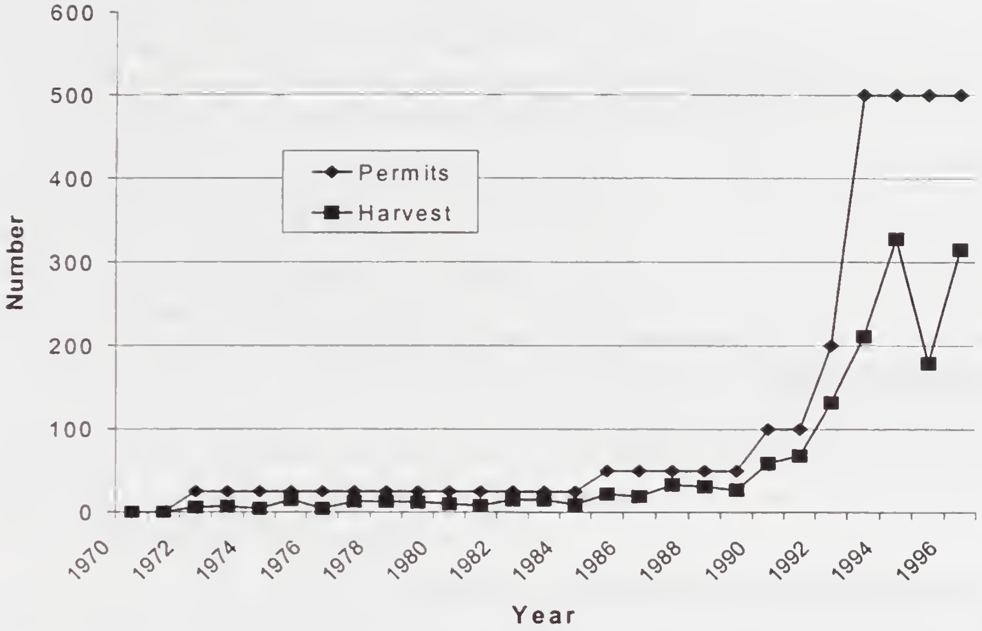


Figure 8.13. Antlerless permits issued and harvest in HD 325, 1970-1996.

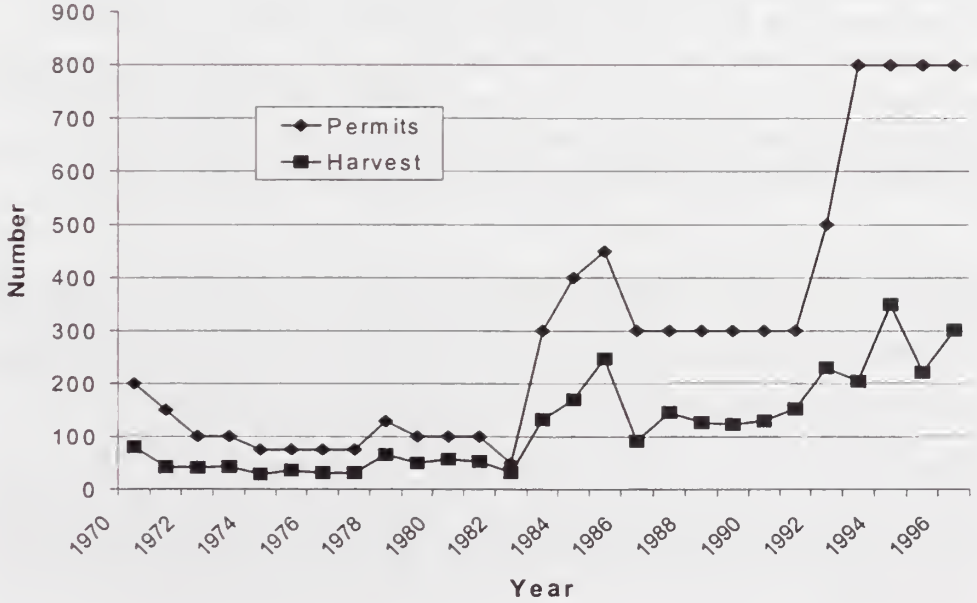


Figure 8.14. Antlerless permits issued and harvest in HD 327, 1970-1996.

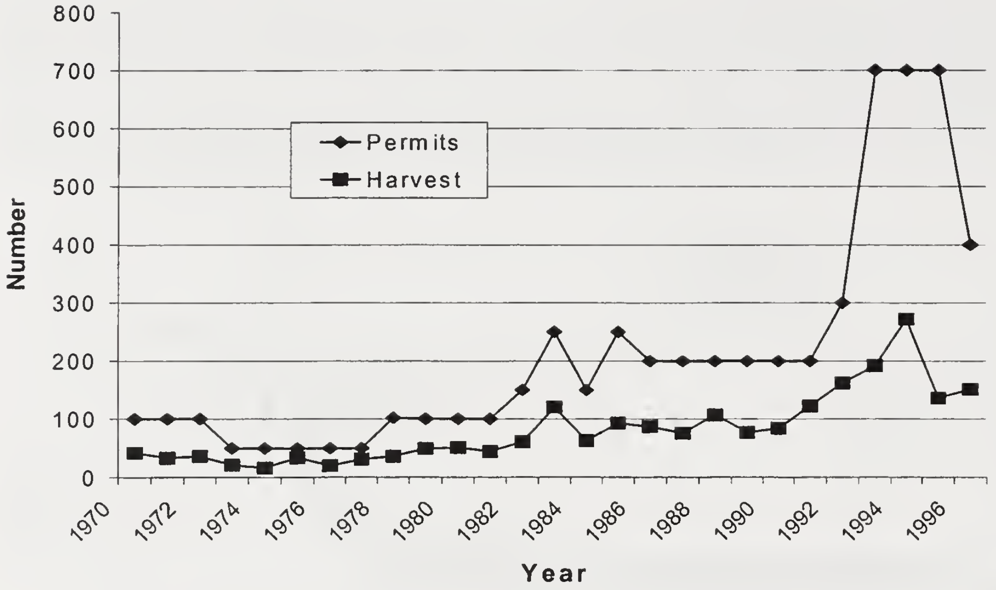


Figure 8.15. Antlerless permits and harvest in HD 330, 1970-1996.

Accuracy of Statewide Harvest Questionnaire

Reported estimates of elk harvest for HD 326 from the SWHQ appeared to over estimate harvest of bulls over the years. Often, more bulls were reported shot in HD 326 than total elk known to exist in that HD. This hunting unit contains a small isolated area of elk habitat and we estimated that about 100-200 elk were present (Table 5.1). We also suspected that hunters may have been confused about boundary locations. We examined original hunter response forms recorded by telephone interviewers during 1995-1997 to determine if the source of harvest overestimates for HD 326 could be determined. The question about nearest landmark/drainage to the kill site especially aided us in our evaluation.

Incorrect responses can occur for a variety of reasons. Hunters may not know where they were, may forget where they were, may purposefully give an incorrect answer for fear of revealing a "secret" hunting spot, or may be confused about hunting district number and boundaries. Also, an interviewer may inadvertently wrongly record a correctly given answer or be unfamiliar enough with an area to not question obviously incorrect responses. Answers may be given that, if correct, reveal an illegal action (shot in wrong HD, shot wrong type of animal, etc.). Alternatively, the answer may be incorrect (wrong HD given) and the animal was legally harvested. Also, multiple hunting districts have the same key drainage names, making it possible for the wrong hunting district to be listed.

With our detailed knowledge of the area, we used the answer to the question about specific location of kill to determine if the hunting district given/recorded was correct. For this analysis, we assumed that the specific location given was correct. Although primarily concerned with information for HD 326, we used the opportunity to examine responses for all Gravelly-Snowcrest HDs (Table 8.8).

Our examination revealed that, except for HD 326, the correct HD of kill was recorded for 89.2% of bulls and 94.4% of antlerless elk. Further, 98.1% of bulls and 97.7% of antlerless elk were correctly recorded as being shot within the Gravelly-Snowcrest population unit. Thus, at the level for which most population analyses were made, the survey was accurate. For HD 326, as suspected, only 34.9% of bull kill locations actually occurred there. For antlerless elk, 78.7% of kills recorded in HD 326 actually occurred there. For bulls, of the errors in kill location wrongly given/recorded as HD 326, 62.0% were actually in HD 324, 25.3% in HD 325, 7.6% in HD 330, and 2.5% each in HDs 322 and 329. For antlerless elk, 33.3% of wrongly given/recorded kill locations were actually in HD 324, 25.0% in HD 325, 16.7% in HD 300, and 8.3% each in HDs 323, 327, and 331. Some incorrect potential locations of kill for HD 326 (such as the East Fork of Blacktail Creek) were on the list used by interviewers. We believe this caused most of the inaccuracy we observed and have had these place names removed from the interviewers list of potential kill locations for HD 326.

The illegal kill data reported in Table 8.8 could be minimal (most people probably do not correctly report illegal kill locations or sex/age violations). However, they also could be an overestimate because if correct kill locations had been given/recorded the animal may have been legally taken. These "self-reports" of illegal kill indicated that 2.5% of the reported bull kill were illegal yearling bulls and 2.0% of bull kills were illegally shot in HDs for which the hunter held an antlerless permit. For antlerless elk, 2.6% of reported kill was not in the HD for which the hunter held a permit and 0.8% of the kill was by hunters who did not hold an antlerless permit.

Gravelly-Snowcrest Check Stations

We operated the Upper Ruby check station each year, 1984-1996. This station also was open during some years dating back to the 1950s. During 1984-1985, 2-3 check stations were operated on the east side of the Gravelly Mountains south of Ennis. In 1986 these stations were combined into one station at Ennis and a new station was opened on the Blacktail Road, south of Dillon. The Ruby, Blacktail, and Ennis stations were all operated each year, 1986-1996 (Table 8.9). Portions of hunting districts 325 and 327 were not well covered by the check stations. Because these areas remained open to harvest of any bull longer than the rest of the Gravelly-Snowcrest Mountains, check station data likely underrepresented yearling bull harvest during 1984-1989. We verified this from statewide hunter questionnaire data, which estimated that yearlings comprised 31.1% of bull harvest in Gravelly-Snowcrest HDs during 1986-1989. Yearling bulls were a mean of 25.2% of bulls recorded at check stations during the same period.

Table 8.8. Evaluation of accuracy of Statewide Hunter Harvest Questionnaire responses for Gravelly-Snowcrest hunting districts, 1995-1997.

Hunting District	Bull Elk			Antlerless Elk		
	Correct HD^{a}	Correct Population^{b}	Illegal^{c}	Correct HD^{a}	Correct Population^{b}	Illegal^{c}
323	31/44(70.5)^{d}	42/44(95.5)	2, 1=A, 1=B	112/132(84.9)	118/132(89.4)	4, 4=C
324	103/107(96.3)	106/107(99.1)	3, 1=A, 2=B	289/296(97.6)	295/296(99.7)	5, 3=C, 2=D
325	57/67(85.1)	65/67(97.0)	5, 3=A, 2=B	154/169(91.1)	165/169(97.6)	5, 4=C, 1=D
326	15/43(34.9)	43/43(100)	4, 3=A, 1=B	37/47(78.7)	44/47(93.6)	9, 8=C, 1=D
327	83/86(96.5)	85/86(98.8)	2, 1=A, 1=B	199/203(98.0)	202/203(99.5)	5, 2=C, 3=D
330	48/57(84.2)	56/57(98.3)	2, 1=A, 1=B	96/100(96)	99/100(99)	5, 4=C, 1=D
Total	337/404(83.4)	397/404(98.3)	18(4.5^{e}), 10=A, 8=B	887/947(93.7)	923/947(97.5)	33(3.5^{e}), 25=C, 8=D
Total w/o HD 326	322/361(89.2)	354/361(98.1)	14(3.9^{e}), 7=A, 7=B	850/900(94.4)	879/900(97.7)	24(2.7^{e}), 17=C, 7=D

[a] Numbers (%) of elk shot reported/recorded in correct hunting district based on landmarks also reported.

[b] Even if incorrectly reported/recorded by hunting district, number(%) correctly reported within the Gravelly-Snowcrest population area.

[c] Probable self-reported illegal kills. A= reported shooting spike or branched-yearling bull rather than BTB, B= reported shooting a bull within the hunting district for which they held an antlerless permit (illegal in these years), C= reported shooting an antlerless elk in another hunting district than for which their permit was valid, D= reported shooting an antlerless elk, but did not hold a valid antlerless permit, only a general elk license.

[d] Number correct/Total number (%).

[e] Minimum % illegal harvest reported.

Table 8.9. Elk harvest, Gravelly-Snowcrest check stations, 1984-1996.

Check Station[a]	Year	No. Hunters	Males			Antlerless			
			Yearling	≥2 years old	Tot. Males	Females	Calves	Antlerless	Calves:100 cows
Ruby	1984	1,698	11	23	34	57	11	68	19.3
	1985	1,623	10	46	56	82	27	109	32.9
	1986	2,172	11	42	53	47	14	61	29.8
	1987	2,135	14	36	50	69	18	87	26.1
	1988	2,096	14	39	53	62	19	81	30.7
	1989	1,832	4	28	32	55	27	82	49.1
	1990	1,830	0	34	34	43	15	58	34.9
	1991	1,522	0	50	50	51	21	72	41.2
	1992	1,738	0	47	47	77	23	100	29.9
	1993	2,019	0	56	56	62	19	81	30.7
	1994	1,964	0	60	60	74	22	96	29.7
	1995	2,034	1[b]	41	42	47	12	59	25.5
	1996	1,625	0	65	65	66	14	80	21.2
Blacktail	1986	1,882	11	20	31	28	9	37	32.1
	1987	1,930	11	29	40	38	7	45	18.4
	1988	1,831	11	25	36	53	3	56	5.7
	1989	2,256	14	40	54	48	23	71	47.9
	1990	1,781	1[b]	22	23	34	9	43	26.5
	1991	1,887	1	60	61	77	21	98	27.3
	1992	2,214	1[b]	40	41	64	18	82	28.1
	1993	2,045	0	28	28	37	14	51	37.8
	1994	2,051	1	82	83	72	24	96	33.3
	1995	1,980	0	18	18	44	7	51	15.9
	1996	1,767	1[b]	63	64	72	31	103	43.1
Ennis	1986	1,035	11	27	38	24	7	31	29.2
	1987	1,010	6	28	34	28	8	36	28.6
	1988	1,017	11	31	42	63	17	80	27.0
	1989	913	8	29	37	33	8	41	24.2
	1990	897	1[b]	27	28	42	6	48	14.3
	1991[c]	678	0	41	41	46	19	65	41.3
	1992	909	0	31	31	42	12	54	28.6
	1993	901	0	36	36	37	7	44	18.9
	1994	1,106	1[b]	63	64	82	13	95	15.9
	1995	1,147	1[b]	26	27	27	6	33	22.2
	1996	1,110	2[d]	41	43	66	16	82	24.2
ALL[a]	1984	3,425	16	40	56	97	25	122	25.8
	1985	3,124	12	72	84	110	31	141	28.2
	1986	5,089	33	89	122	99	30	129	30.3
	1987	5,075	31	93	124	135	33	168	24.4
	1988	4,944	36	95	131	178	39	217	21.9
	1989	5,001	26	97	123	136	58	194	42.7
	1990	4,508	2[b]	81	83	119	30	149	25.2
	1991[c]	4,087	1	151	152	174	61	235	35.1
	1992	4,861	1[b]	118	119	183	53	236	29.0
	1993	4,965	0	120	120	136	40	176	29.4
	1994	5,121	2[d]	205	207	228	59	287	25.9
	1995	5,161	2[b]	83	85	118	25	143	21.2
	1996	4,502	3[e]	169	172	204	61	265	29.9

[a] The Upper Ruby Check Station was the only one operated each year 1984-1996. In 1984 and 1985, 2-3 other stations were manned on the east side of the Gravellys. In 1986, those stations were combined into one station at Ennis and a new station was opened on the Blacktail Road south of Dillon.

[b] Illegal kills.

[c] Ennis check station not operated opening day 1991 because of unsafe conditions.

[d] One legal, one illegal.

[e] One legal, 2 illegal.

Periodic check station data at the Ruby location from 1950-1980 (Table 8.10) indicated that yearling bulls comprised an increasing proportion of the harvest over the period. The statewide hunter questionnaire provided similar data (Figs. 8.9 and 8.10). Data for the Ruby, which is the most heavily hunted part of the area, indicated a lower percent of bulls ≥2 years old than statewide questionnaire information for the entire Gravelly-Snowcrest complex (Table 8.10). The decline in older bulls in the harvest apparently started in the late 1960s for the entire area, but may have started during the early-mid 1960s in the Ruby area.

Bull and antlerless harvest recorded at check stations were positively correlated with the estimates from the statewide questionnaire (Bull - $R^2 = 0.876$, $F = 63.45$, $P = 0.00002$; Antlerless – $R^2 = 0.784$, $F = 32.64$, $P = 0.0003$). During 1986-1996, elk harvest determined by the SWHQ could be predicted from check station data. However, number of hunters recorded at check stations was not correlated with the number estimated by the statewide questionnaire ($R^2 = 0.004$, $F = 0.037$, $P = 0.85$). This result was not surprising given multiple recording of the same hunter(s) at check stations. Annual changes in hunter numbers must be determined by the SWHQ. When comparisons between check station and SWHQ results were separated as bulls (Fig. 8.16), cows (Fig. 8.17), and calves (Fig. 8.18) it was apparent that harvest of calves was substantially underestimated with the SWHQ. As determined for deer (Hamlin and Mackie 1989), hunters were reluctant to report shooting young-of-the-year. The percent calves recorded at check stations was 1.98 times that reported on the statewide hunter questionnaire. The calf: 100 cow ratio of the harvest recorded at check stations averaged 63.7% of the estimated calf: 100 cow ratio for the population, indicating hunter selection against calves. However, no consistent linear relationship occurred between calf:100 cow ratio recorded at the check stations and population calf: 100 cow ratio ($R^2 = 0.167$, $F = 1.80$, $P = 0.21$). We detected the unusually low calf: 100 cow ratio of 1995-1996 at the check station, however.

Table 8.10. Ruby check station results prior to the current study period.

Year	≥2 Year Old Males	% Males ≥2 Years	Yearling Males	Total Males	Cows	Calves	Total Antlerless	% Males ≥2 Years SWHQ HD 324	% Males ≥2 Years SWHQ entire area
1950	140	78.7	38	178	219	79	298		
1954	37	69.8	16	53	76	39	115		
Mean 1950s		**74.3**							
1962[a]	4	15.4	22	26	42	54	96		69.4
1968-69	12	**24.0**	38	50					52.0
1970	8	16.0	42	50	49	5	54	39.3	36.0
1971	6	15.4	33	39	28	9	37	33.5	35.0
1972	5	17.2	24	29	28	12	40	27.0	33.5
1973	11	18.3	49	60	17	4	21	26.2	35.6
1974	9	22.5	31	40	11	2	13	27.5	36.3
Mean **1970-74**		**17.9**						30.7	35.3
1975,76, 78,80	3	**9.1**	30	33				21.2	28.3

[a] For the entire Gravelly-Snowcrest area, check station results were 33 males ≥2 years old (39.3%) and 51 yearling males.

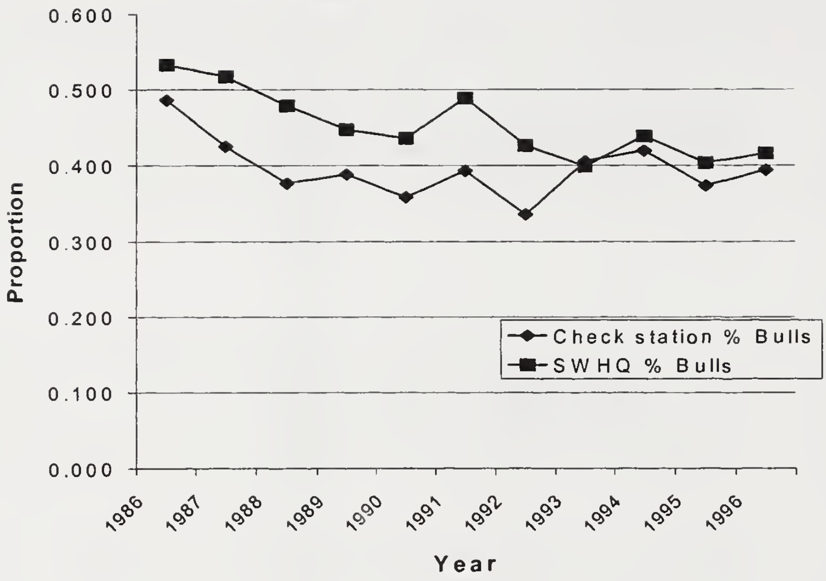


Figure 8.16. Proportions of bull elk in the harvest recorded at check stations and in the statewide harvest questionnaire (SWHQ), Gravelly-Snowcrest Mountains, 1986-1996.

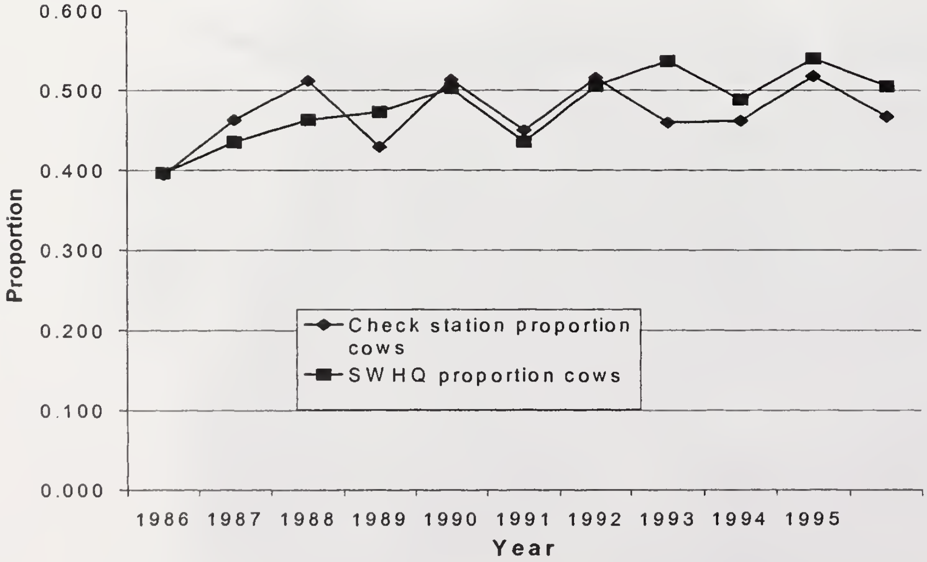


Figure 8.17. Proportions of cow elk in the harvest recorded at check stations and on the statewide hunter questionnaire (SWHQ), Gravelly-Snowcrest Mountains, 1986-1996.

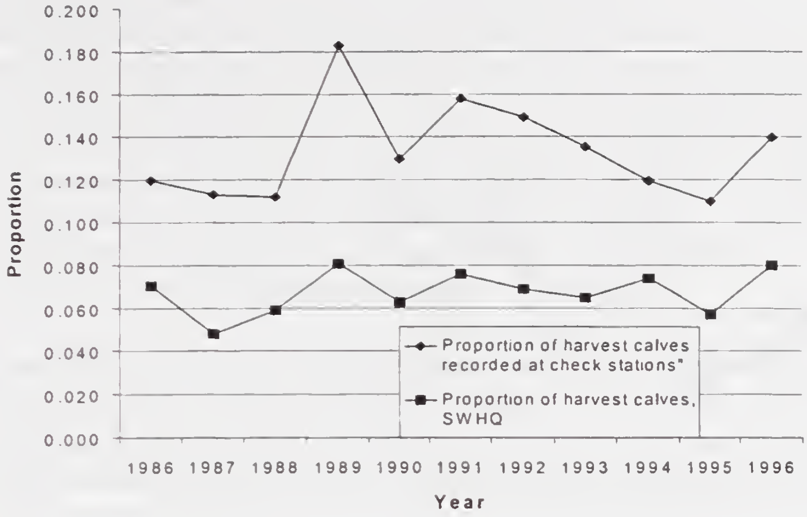


Figure 8.18. Proportions of calf elk in the harvest recorded at check stations and on the statewide hunter questionnaire (SWHQ), Gravelly-Snowcrest Mountains, 1986-1996.

Interaction of Hunter Numbers, Elk Numbers, and Elk Harvest

It seems logical to assume that numbers of hunters and numbers of elk available to harvest both would affect numbers of elk harvested. To examine a possible relationship among these factors, we plotted observed bull kill (Fig. 8.19) and antlerless kill (Fig. 8.20) against measures of elk numbers and hunter numbers for Gravelly-Snowcrest HDs during 1985 – 1996. Because trend counts can vary year-to-year with factors other than elk numbers, we used a trend line of the trend counts similar to that in Figure 5.1 to represent elk numbers available to harvest for 1985 – 1996. We then used the bull kill/elk numbers figure for 1985 as a base point to calibrate predicted bull kill during 1986 – 1996 based on changes in elk numbers from the trendline. This line predicted bull kill as if numbers of bulls killed in a year were directly proportional to the number of elk in the population (Fig. 8.19). Similarly, we predicted bull kill during 1986 – 1996 as if it was directly proportional to the number of hunters holding a general elk license and hunting in Gravelly-Snowcrest HDs. This predictive line was also calibrated with 1985 as the base point for bull kill/hunter numbers (Fig. 8.19). We made the same predicted kill calculations for antlerless elk versus elk numbers, again using 1985 as the base point (Fig. 8.20). Because only those holding permits could kill antlerless elk, we made an adjustment to this calculation. We assumed that percent success for antlerless permits should increase from the lowest observed success at the lowest elk population to the highest observed success at the highest elk population and calculated a regression based on those assumptions for percent success at observed population level. To predict antlerless elk kill as if it was directly related to hunter numbers (permits issued), we multiplied average percent success during 1985 – 1996 by permits issued each year to predict antlerless kill (Fig. 8.20).

Over the 11-year period, observed kill of bull elk increased as hunter numbers and elk populations increased (Fig. 8.19). However, year-to-year, bull kill did not closely track

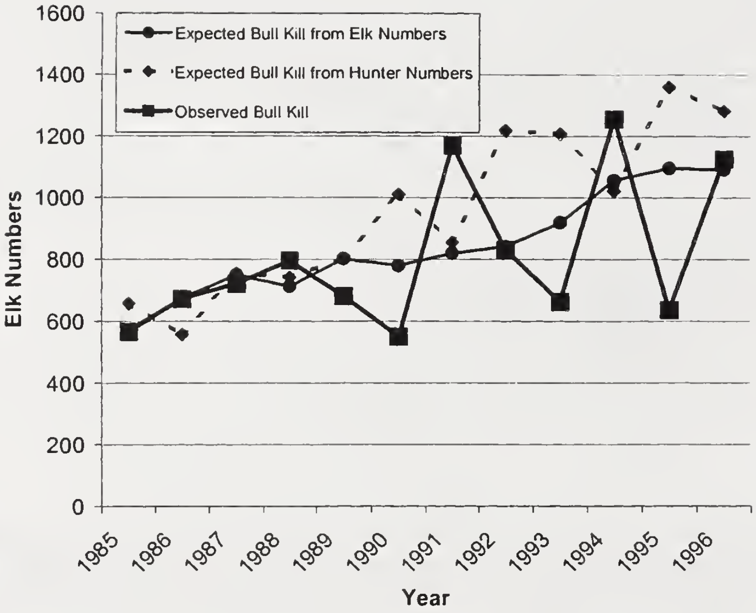


Figure 8.19. Observed kill of bull elk, Gravelly-Snowcrest Mountains, 1985 – 1996 compared to predicted kill assuming a direct relationship of hunter numbers and elk numbers to kill of bulls.

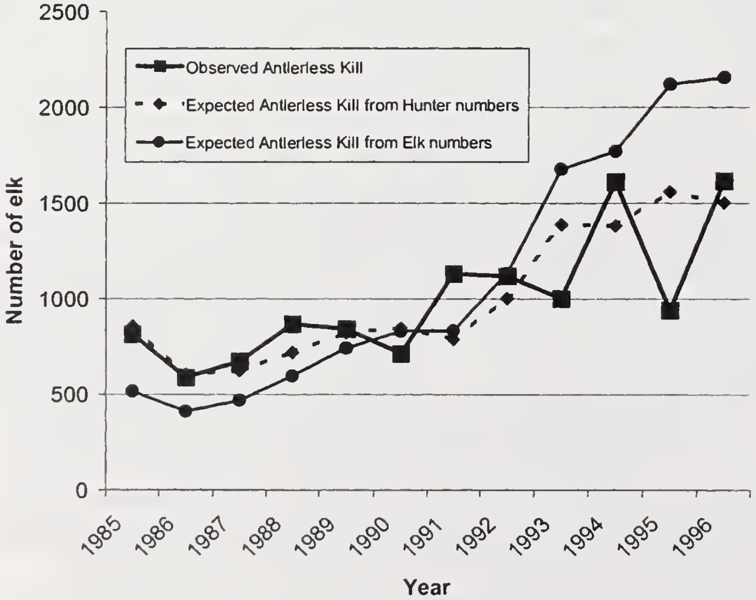


Figure 8.20. Observed kill of antlerless elk, Gravelly-Snowcrest Mountains, 1985 – 1996 compared to predicted kill assuming a direct relationship of hunter numbers and elk numbers to kill of antlerless elk.

predicted kill based on hunter or elk numbers. In fact, annual trends in hunter numbers and bull kill often moved in opposite directions (Fig. 8.19, 1990 – 1995). Wide fluctuations in observed bull kill also occurred compared to the smooth upward trend predicted by elk numbers alone (Fig. 8.19). This indicated that although there may be a very general relationship among bull kill, hunter numbers, and elk numbers, annual weather conditions that affected elk and hunter distribution probably played the major role in annual bull elk kill. Unusually cold weather with snow occurred early during 1991. 1994, and 1996 hunting seasons. Unusually mild and dry weather occurred during 1990, 1993, and 1995 hunting seasons.

There was a closer relationship of observed antlerless kill and kill predicted based on hunter numbers and elk populations than we observed for bulls (Figs. 8.19, 8.20). However, here also, there was little relationship on an annual basis (Fig. 8.20). Again, either extremely severe or mild weather during the hunting season appeared to most affect annual kill (Fig. 8.20, severe – 1991, 1994, 1996; mild – 1990, 1993, 1995).

Hunter and elk numbers may affect long-term trends in elk harvest, but annual kill was most affected by weather. This is similar to findings by Youmans, C. (1992) for the Bitterroot drainage. There, he found annual weather effects to override the effects of hunter numbers, amount of open roads, amount of timber cutting, and other factors in determining annual variation in elk harvest.

CHAPTER 9

DISTRIBUTION, MOVEMENTS, AND HOME RANGE

Distribution

A total of 12,951 locations of 856 individually marked elk was used for analysis of elk distribution. For some analyses, fewer numbers were used, such as when locations were clipped to only the Gravelly Landscape Analysis Area (GLAA) or Forest Boundaries. A total of 12,005 (92.7%) locations was within the GLAA, 608 (4.7%) were in Idaho, 284 (2.2%) were in other Montana hunting units, 46 (0.35%) were in Yellowstone National Park (YNP), and 8 (0.06%) were in other portions of Wyoming. Of locations in other Montana hunting units, 222 (78.2%) or 1.7% of all locations were in HD 361. Of locations within YNP, 56.5% were in Wyoming, 34.8% in Montana, and 8.7% in Idaho.

A plot of all elk locations (Fig. 9.1) illustrates Gravelly-Snowcrest elk distribution from a landscape perspective. This plot excludes one location of a bull elk that emigrated to near Ten Sleep, Wyoming, about 400 airline km (250 miles) east of his marking location on the BTWMA as a 9-month-old calf. The minimum convex polygon (MCP) enclosing these locations covered 39,037 km^2 (15,072 mi^2). The major areas of use for this population were the Gravelly, Snowcrest, Greenhorn, Blacktail, Henry's Lake, and Centennial Mountain ranges (Fig.9.1). Elk locations outside these areas generally represented a permanent dispersal (emigration). Elk from the Gravelly-Snowcrest population emigrated to the Sand Creek population in Idaho, the populations associated with the National Elk Refuge near Jackson, Wyoming, and the Tobacco Root Mountains, Madison Range, and Lima Peaks areas of Montana. Interestingly, no elk were observed to emigrate to the Ruby Mountains, within the GLAA.

A slightly closer view (Fig. 9.2), without the 34 most widely dispersed locations, indicated some general distribution patterns. Elk generally did not use broad, open valleys such as the Centennial and Blacktail Valleys, or even narrower mountain valleys such as the Ruby. Elk obviously traveled through these areas, but time spent was so brief that locations were rarely recorded. Also, the distribution in Figure 9.2 indicated that elk made little use of the rocky spine areas of mountain ranges and large, open meadows at and near timberline. The MCP enclosing these locations was 11,746 km^2 (4,535 mi^2).

When we excluded the 60 furthest dispersed points, MCP was 9,764 km^2 (3,770 mi^2). However, we estimated that 2,849 km^2 (1,100 mi^2) were areas of non-use by elk. Thus the area used by the Gravelly-Snowcrest elk population was 6,915 km^2 (2,670 mi^2).

Within the GLAA, elk were not distributed proportional to land ownership (Table 9.1). For total distribution, positive association with MFWP and USFS lands accounted for 56% and 29%, respectively, of differences ($\chi^2_5 = 38,696$, $P < 0.0000$). During winter, positive association with MFWP lands accounted for 97.7% of the difference ($\chi^2_5 = 57,227$, $P < 0.0000$). This should not be surprising, because the lands were purchased as elk winter range.

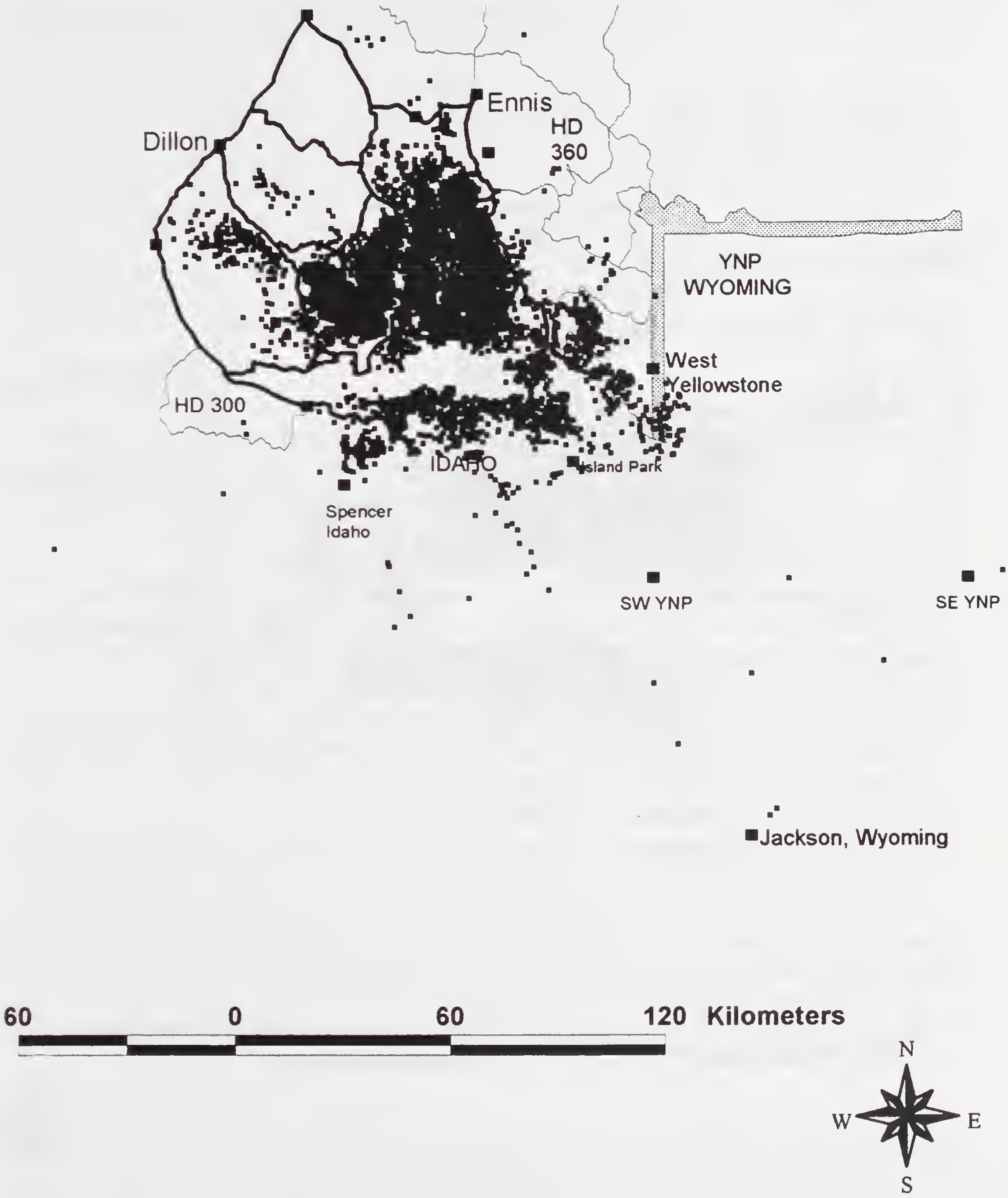


Figure 9.1. Landscape perspective of distribution of marked elk from the Gravelly-Snowcrest population.

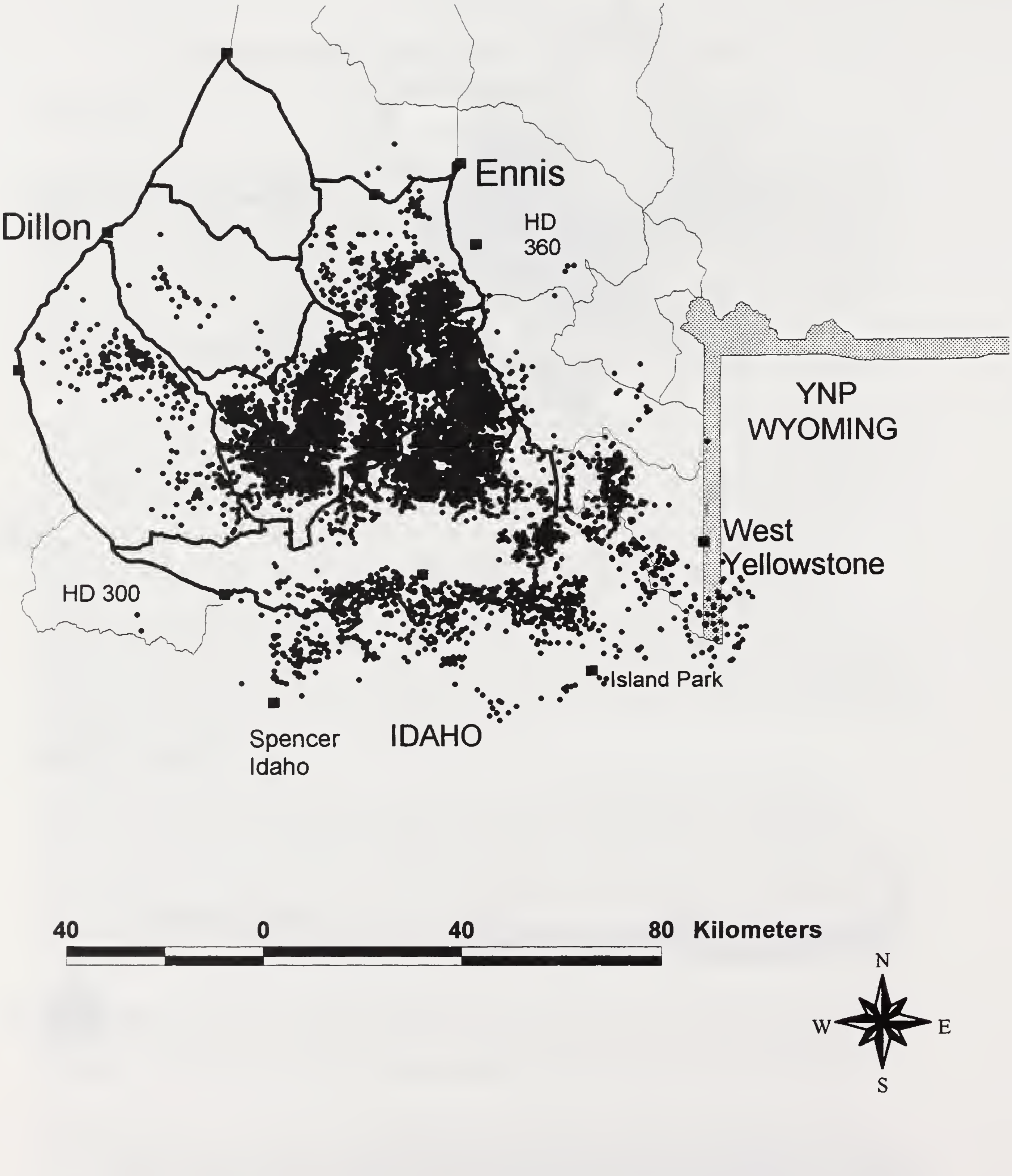


Figure 9.2. Landscape view of distribution of marked elk from the Gravelly-Snowcrest population without the 34 most dispersed locations.

Table 9.1. Percent distribution of relocation sites of marked elk during 1984-1997 relative to land ownership within the Gravelly Landscape Analysis area.

Land Owner	% ownership	Total Elk[a]	Winter[b]	Antlerless Kill[c]	Antlerless Non-kill[c]	Bull Kill[c]	Bull Non-kill[c]	All other Seasons[d]
Private	39.2	7.3	10.8	8.0	5.8	8.7	6.4	6.3
U.S. Forest Service	23.8	70.8	37.0	72.1	82.6	72.5	81.6	80.0
Bureau Land Mgmt.	21.4	5.4	4.9	5.3	8.7	8.7	8.0	5.2
State Lands - DNRC	12.6	2.6	2.1	5.3	1.3	5.8	3.2	2.8
USFWS	2.0	0.2	-	0.4	0.6	0.7	-	0.2
MFWP	0.9	13.7	45.3	8.8	1.0	3.6	0.8	5.5
No. locations		12,005	2,554	262	783	138	125	8143

[a] All elk relocations, 1984-1997.

[b] Winter = January, February, and March relocations.

[c] General hunting season (20 October - 1 December). Kill = kill site of marked elk. Non-kill = radio-relocations of live elk during the period.

[d] Elk locations during 1 April – 19 October and 2 December- 31 December.

Distribution of antlerless elk kill during the general hunting season was disproportionately positively associated with MFWP (37% of variation) and USFS (44% of variation) lands and negatively associated with private lands (11% of variation) (χ^2_5 = 591.6, $P < 0.0000$). Distribution of living antlerless elk during the general hunting season (χ^2_5 = 1,513, $P < 0.0000$) was positively associated with USFS lands (75.5% of variation) and negatively associated with private lands (14.8% of variation). Most variation in location of bull elk kill sites (χ^2_5 = 201.6, $P < 0.0000$) and relocation sites of living bull elk (χ^2_5 = 229.8, $P < 0.0000$) during the general hunting season was positively associated with USFS lands (67% and 75%, respectively) and negatively associated with private lands (16% and 15%, respectively). Distribution of kill sites of antlerless elk compared to non-kill sites (relocation sites of living elk) indicated that disproportionate numbers of kill sites occurred on MFWP (73% of variation) and DNRC-(SL) (22% of variation) lands (χ^2_5 = 183.5, $P < 0.0000$). Distribution of kill sites of bull elk compared to non-kill sites also indicated that disproportionate numbers of kill sites occurred on MFWP (71% of variation) and SL (18% of variation) lands (χ^2_5 = 22.6, $P = 0.0004$). This result was likely related to open hunter access to lower elevation lands of mild topography, especially during late hunting season and indicate the relative importance of MFWP and SL lands to hunter harvest. USFS lands also are open access, but contain more terrain that is physically difficult to access because of distance from roads and ruggedness. The greatest numbers of elk killed, however, were on USFS lands.

Herd Ranges

The term herd range used here is equivalent to population-habitat unit described for mule deer by Pac et al. (1991) and is based on winter range occupancy. Herd range is the yearlong distribution and habitat occupied by females of the herd or sub-population wintering at a specific site. We delineated 10 herd ranges for elk in the Gravelly-Snowcrest population based on movements of elk marked on those winter ranges. Elk that permanently dispersed to other winter ranges were included with those herd ranges after dispersal, but some intermediate movements could be included with either area.

Of 201 females marked on the Wall Creek Wildlife Management Area (WCWMA) in HD 323, 170 (84.6%) used areas traditionally associated with Gravelly-Snowcrest hunting units (Fig. 9.3) during summer and autumn. Fourteen (7.0%) used areas in Idaho, 2 (1.0%) used YNP, and 15 (7.5%) used HD 361. Percent distribution of locations during the general hunting season (Table 9.2) indicated 63.6% in HD 323, 12.5% in HD 327, 8.6% in HD 324, 3.1% in HD 330, 3.9% in HD 361, and 6.7% in Idaho.

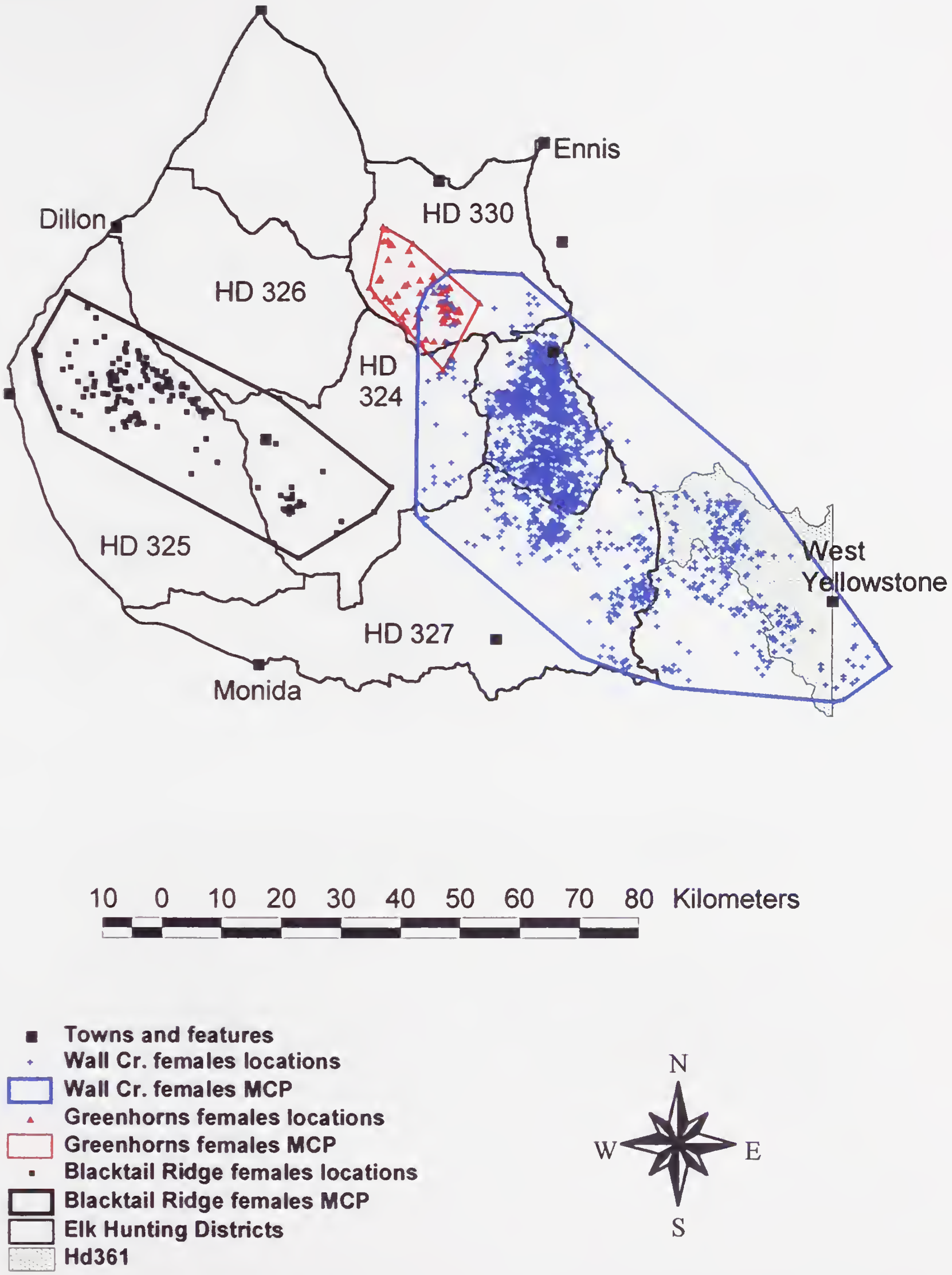
All 8 females marked on Blacktail Ridge remained in the Gravelly-Snowcrest area (Fig. 9.3). During the general hunting season, 69.6% locations were in HD 325 and 30.4% in HD 324. Five female elk marked in the Greenhorn Mountains remained there (Fig. 9.3). Neither of 2 locations outside HD 330 was during the hunting season.

Of 184 females marked on the BTWMA, 174 (94.6%) remained within the Gravelly-Snowcrest area (Fig. 9.4). Nine (4.9%) spent summer and autumn in Idaho and 1 (0.5%) in YNP. During the general hunting season, 73.6% of locations were in HD 324, 21.5% in HD 327 and 2.3% in Idaho (Table 8.2). All 24 females marked on the Cherry-Morgan Creek winter range remained in Gravelly-Snowcrest hunting districts. We excluded one female using HD 327 in summer from the herd range plot (Fig. 9.4). During the general hunting season, 50.0% of locations were in HD 330, 31.8% in HD 323, and 9.1% each in HDs 324 and 327 (Table 9.2).

Seven (63.6%) of 11 females marked on the Basin-Sage winter range spent summer-autumn in Idaho (Fig. 9.5). During the general hunting season, 46.9% of locations were in HD 327, 34.4% in Idaho, and only 12.5% in the wintering area of HD 325 (Table 9.2). Distribution of five females captured and marked on this winter range during 1978-1981 was similar (H. Chrest, unpubl. data). Three were shot in Idaho, one in HD 327, and one used HD 300 during summer-autumn. All 11 females marked on the Warmsprings Creek winter range in the Ruby drainage remained within the Gravelly-Snowcrest area (Fig. 9.5). During the general hunting season, 67.9% of locations were in HD 324 and 30.4% in HD 330. Both of the females marked in the Sweetwater Hills remained there.

Table 9.2. Percent distribution of relocations for female elk by hunting district or area during the general hunting season (20 Oct. – 1 Dec.) by herd range of marking.

		Hunting District or area									
Herd Range	Number Locations	323	324	325	326	327	330	360	361	Idaho	YNP
Basin-Sage Cr.	32		6.3	12.5		46.9				34.4	
Blacktail WMA	349	1.4	73.6	0.6		21.5	0.3		0.3	2.3	
Blacktail Ridge	23		30.4	69.6							
Cherry-Morgan	66	31.8	9.1			9.1	50.0				
Robb-Ledford	88		96.6			1.1				2.3	
Wall Cr. WMA	360	63.6	8.6			12.5	3.1	1.4	3.9	6.7	0.3
Warmsprings Cr.	56	1.8	67.9				30.4				


Ennis
HD 330
Dillon
HD 326
HD 324
HD 325
West Yellowstone
HD 327
Monida
10 0 10 20 30 40 50 60 70 80 Kilometers
Towns and features
Wall Cr. females locations
Wall Cr. females MCP
Greenhorns females locations
Greenhorns females MCP
Blacktail Ridge females locations
Blacktail Ridge females MCP
Elk Hunting Districts
Hd361
N
W
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S

Figure 9.3. Herd ranges for Wall Creek, Blacktail Ridge, and Greenhorn female elk.

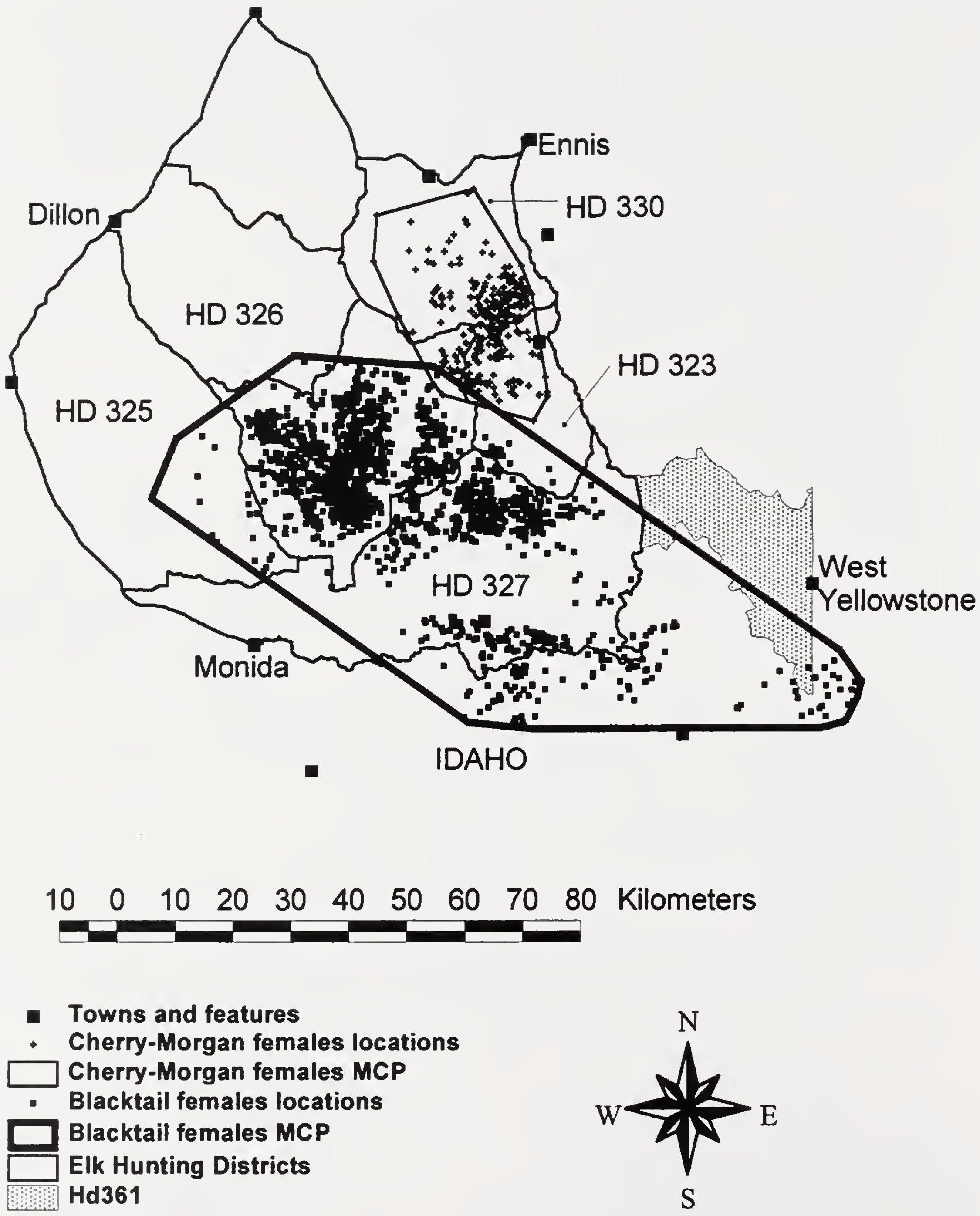


Figure 9.4. Herd ranges for Blacktail and Cherry-Morgan female elk.

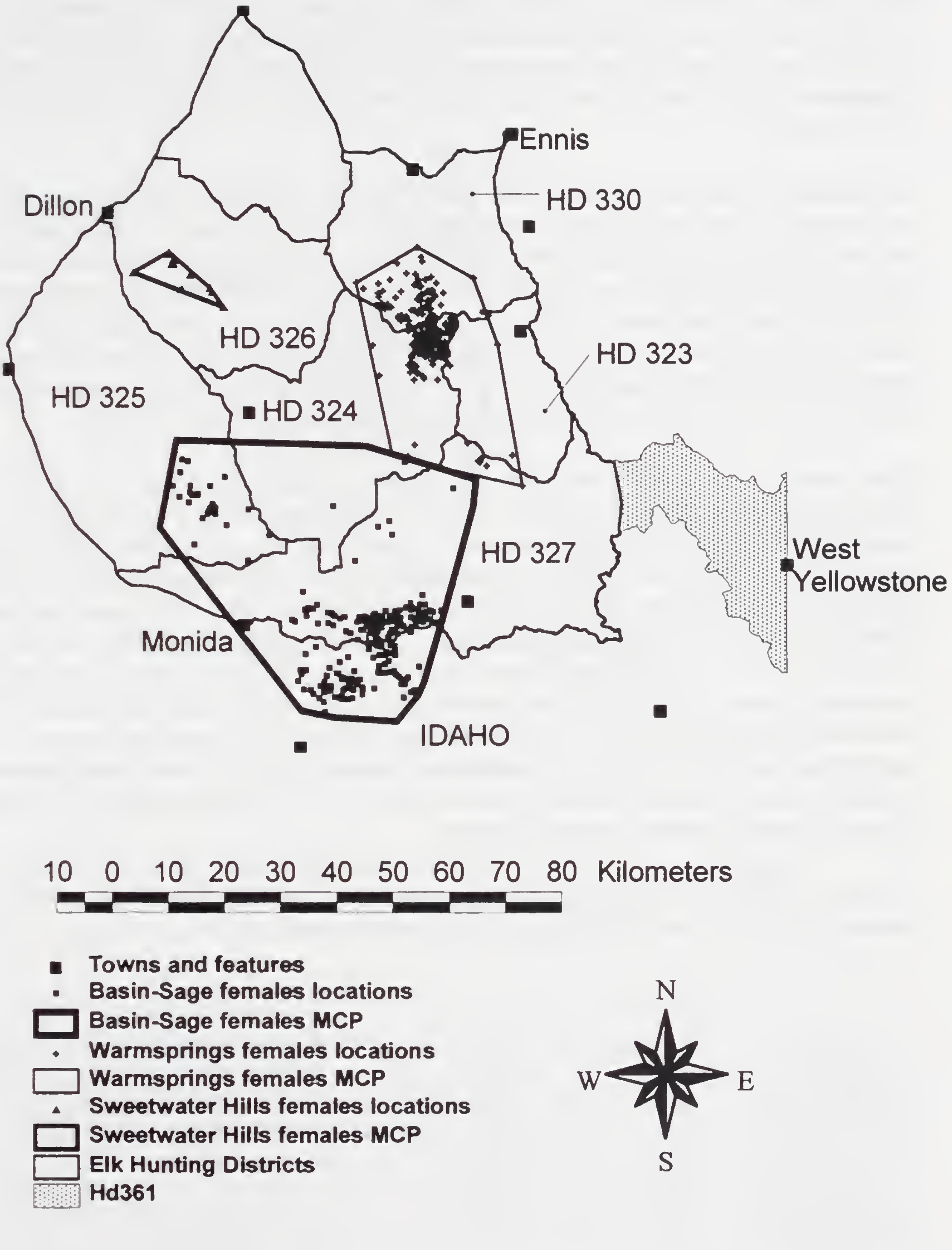


Figure 9.5. Herd ranges for the Warmsprings, Sweetwater Hills, and Basin-Sage Creek female elk.

Of 33 females marked on the Robb-Ledford winter range, 32 (97%) remained in Gravelly-Snowcrest hunting districts and one (3%) spent summer-autumn in Idaho (Fig. 9.6). During the general hunting season, 96.6% of locations were in HD 324. The 3 females marked on the Axolotl winter range remained within HD 330, with the exception of 2 locations.

A possible 11th herd range was for elk that wintered in the Clark Canyon area. We had no radiocollared elk there. Some elk from Blacktail Ridge may have interacted with these elk and the winter ranges may have been partially interchangeable. Elk also wintered in the South Centennials in the Corral Creek area, the North Centennials in the Landon Ridge – Metzel Creek areas, and at Sheep Creek - Little Mile Creek areas during early winter or throughout mild winters. Later in winter, or during more severe winters, most South Centennial elk appeared to move to Basin-Sage Creek, North Centennial elk moved to the BTWMA, and Sheep-Mile Creek elk moved to the WCWMA.

The average aerial count of antlerless elk on Gravelly-Snowcrest winter ranges during 1994-1995 through 1999-2000 was 7,328. We expanded that by an 80 percent observability rate (9,160), added estimated harvest and wounding loss (10,812), and estimated summer-autumn distribution in proportion to relative numbers and distribution in individual herd ranges. An estimated 8,758 antlerless elk (81.0%) were distributed in Gravelly-Snowcrest hunting districts, 1,816 (16.8%) in Idaho, 43 (0.4%) in YNP, and 195 (1.8%) in HD 361. During the general hunting season (20 Oct. – 1 Dec.), with some movement toward winter range, estimated numbers by area (Table 9.3) shifted somewhat. Estimated numbers presented in Table 9.3 are applicable to recommendation of appropriate numbers of antlerless permits by hunting district for herd management. An average of about 10% of Gravelly-Snowcrest elk were not in Gravelly-Snowcrest hunting districts during Montana's hunting season.

Table 9.3. Estimated numbers of antlerless elk in the Gravelly-Snowcrest population by hunting district or area during the general hunting season (20 Oct. – 1 Dec.).[a]

		Hunting District or area									
Herd Range	Number[a] Antlerless	323	324	325	326	327	330	360	361	Idaho	YNP
Basin-Sage Cr.	2258		142	364		1085				667	
Blacktail WMA	2575	33	1887	19		565	9		11	51	
Blacktail Ridge	807		205	602							
Cherry-Morgan	551	162	49			50	290				
Robb-Ledford	1046		1013			12				21	
Wall Cr. WMA	2553	1582	224			336	87	32	134	151	7
Warmsprings Cr.	316	6	210				100				
Greenhorns[b]	406						406				
Axolotl[b]	148						148				
Sweetwater Hills[b]	152				152						
TOTAL	**10812**	**1783**	**3730**	**985**	**152**	**2048**	**1040**	**32**	**145**	**890**	**7**

[a] Numbers of antlerless elk estimated by dividing mean post-season count (1994-95 through 1999-2000) by 0.80 observability and adding mean harvest and wounding loss back in to estimate pre-season numbers. Distribution is from percentages reported in Table 9.2.

[b] Small sample sizes during hunting season for these HDs used here, but not included in Table 9.2.

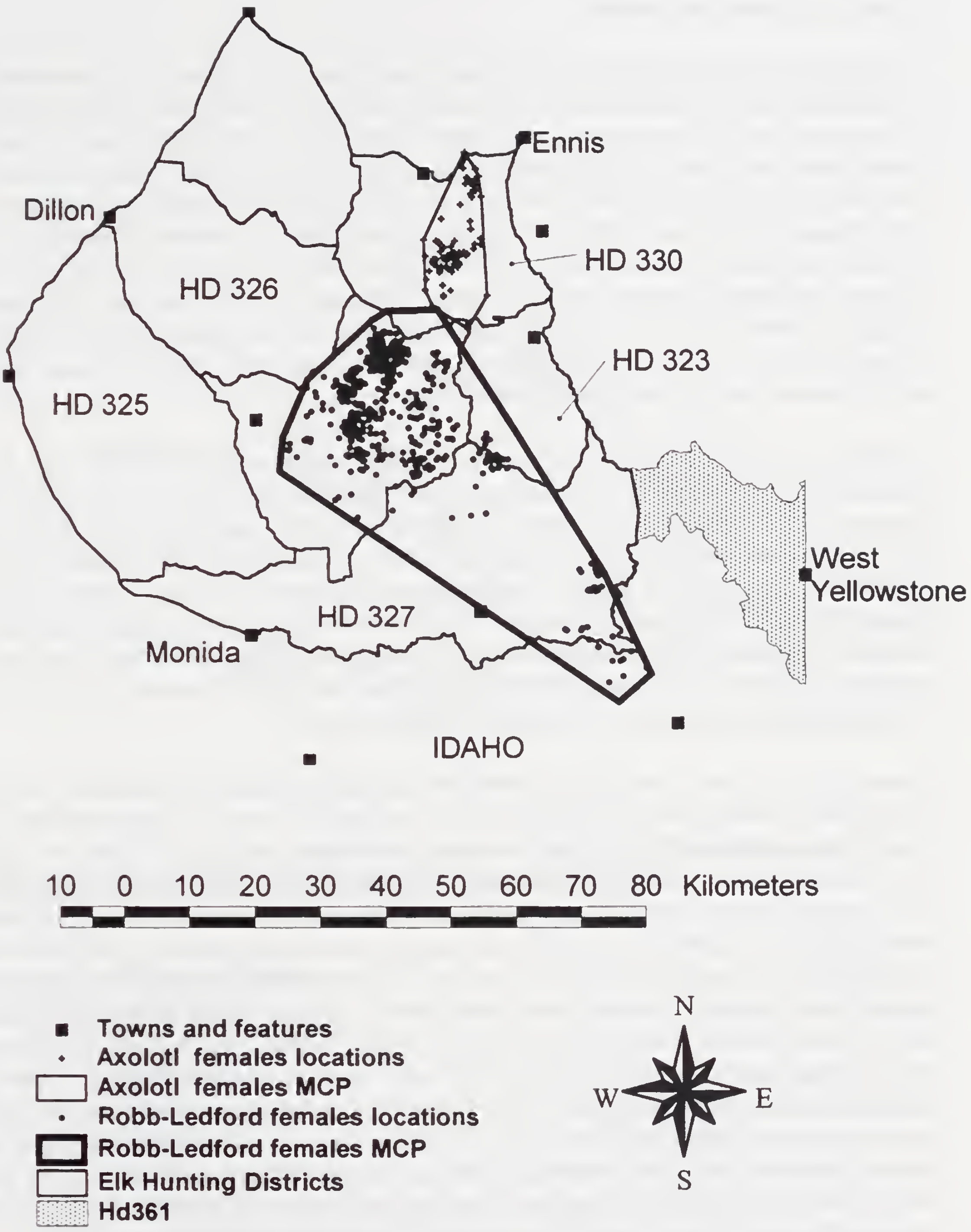


Figure 9.6. Herd ranges for the Robb-Ledford and Axolotl female elk.

Home Range and Movements

This study was not designed to investigate home ranges or habitat use; relocations of radiocollared elk averaged about 1 per month. We present example life home ranges to illustrate patterns of movement and filling of habitat. For our purpose here, we define life home range as all locations of a marked elk made during the study. Because of the high harvest rate of males, relocations of male elk were difficult to obtain over long periods. We obtained relocations of bull 10187 from 10 months to 59 months of age (Fig. 9.7). During that time, he wandered over an area of at least 2,710 km^2 (1,046 mi^2), wintering in at least 3 different locations. We lost contact with him several times during the period, so he likely moved over an even larger area. Following our last radio contact, a bull believed to be this one was observed on the Sand Creek winter range in Idaho. Because we could not be certain, we did not include that location in the plot.

In contrast, bull 10493 (Fig. 9.7) had a life home range of only 99 km^2 (38 mi^2) during a 3.5-year period from 10 to 53 months of age. Two bulls relocated over a 1.5-year period from 9 to 29 months of age showed a similar divergent movement pattern. Bull 10190 (Fig. 9.7) moved over an area of 1,862 km^2 (719 mi^2) and bull 10387 moved over an area of 109 km^2 (42 mi^2). The widely wandering pattern apparently was common among bulls, though their short life and tendency to disperse beyond search range made certainty difficult. Information on winter and summer range fidelity presented later verifies the wandering pattern as common. Individual differences existed, however, such that some males had home range patterns similar to many female elk.

Female elk exhibited a variety of movement patterns that resulted in habitat “fill” (all habitat that is occupied by the elk population at high elk density). The smallest life home ranges were elevational shifts from winter to summer ranges (Fig. 9.8) over an 8 –16 km (5 – 10 mi) distance. These smallest life home ranges were about 60 km^2 (23 mi^2). Some home ranges, in areas with longer drainages, were up to 165 km^2 (64 mi^2). The females used in these examples (Fig. 9.8) did not change their annual pattern of local elevational movements over periods of up to 4 ½ years. At the opposite extreme were female elk that moved long distances between winter and summer-autumn ranges (Fig. 9.9). Female 90791 made annual movements between her winter range on the BTWMA and summer range in and near the western edge of YNP over a 6 ½ year period (Fig. 9.9). The extreme distance between locations was 116 km (72 mi) and minimum convex polygon (MCP) home range was 2,538 km^2 (980 mi^2). The size of the area is misleading because she used little of the expansive area between winter and summer ranges. Of this area, she used only a small area with cover patches along Landon Ridge in transition between summer-autumn range and winter range. She apparently rapidly traversed the rest of the intervening area, which consisted mostly of non-timbered land.

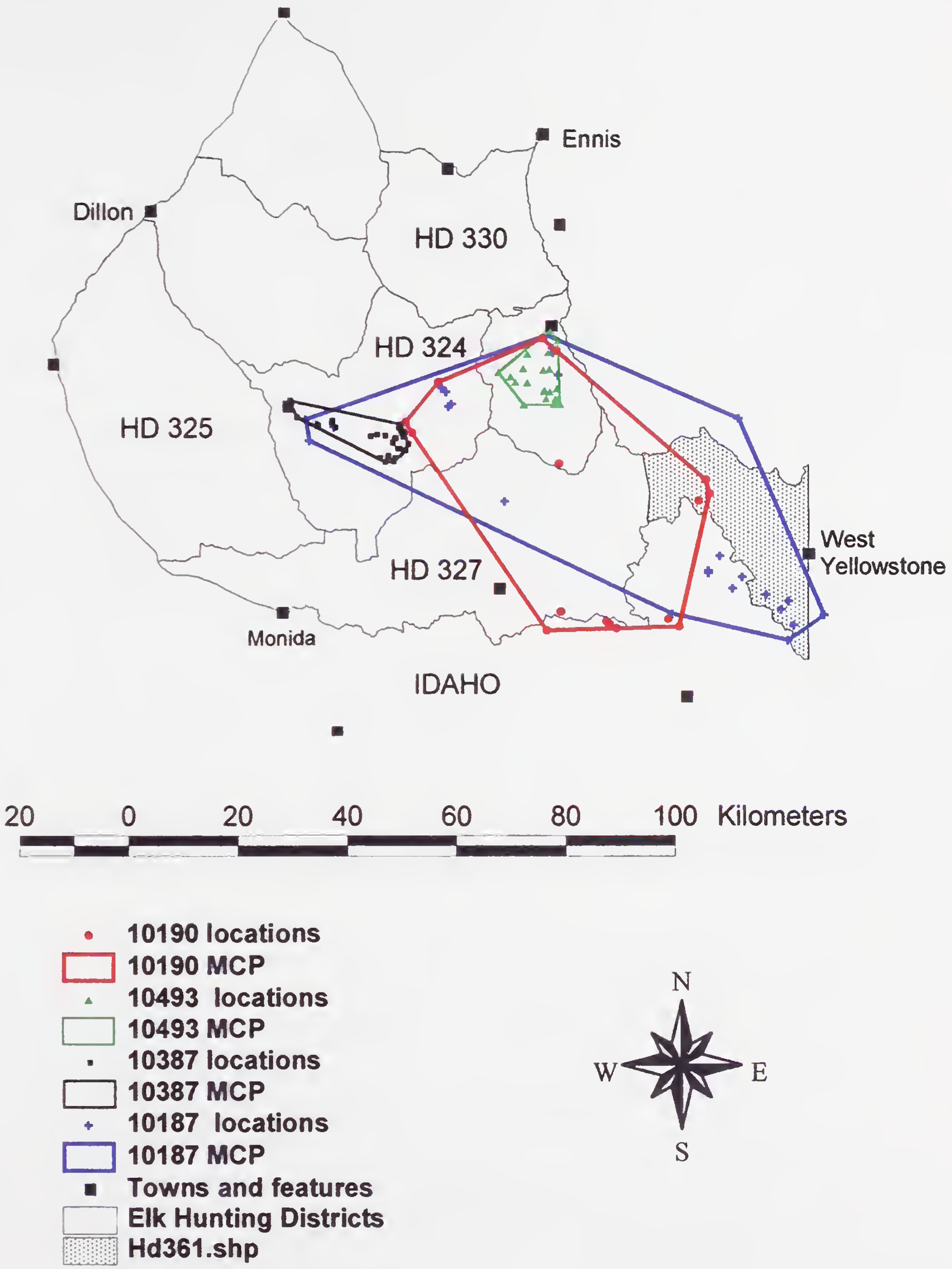


Figure 9.7. Life home ranges of 4 bull elk, Gravelly-Snowcrest Mountains.

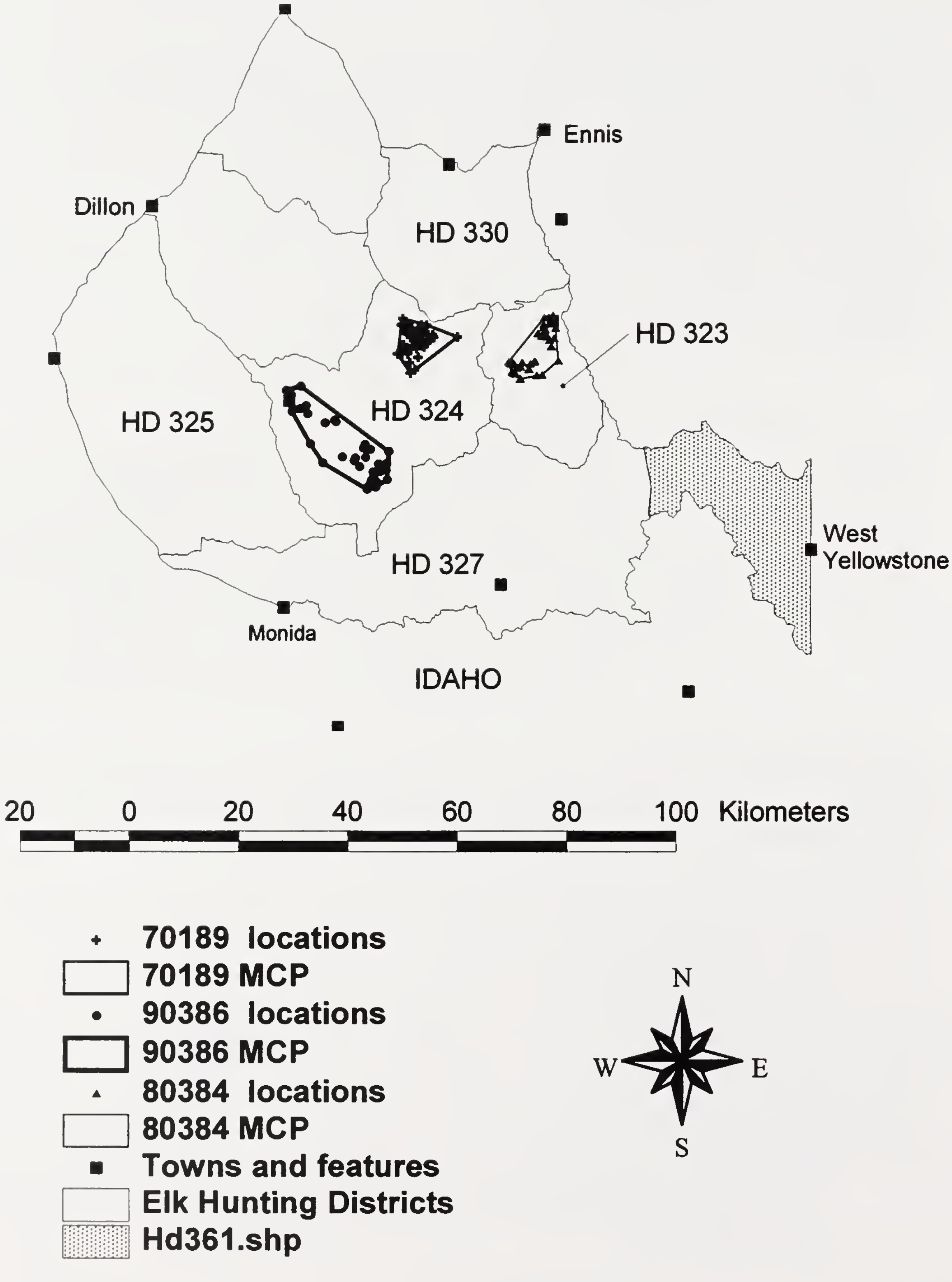


Figure 9.8. Examples of small life home ranges of 3 female elk (elevational movement).

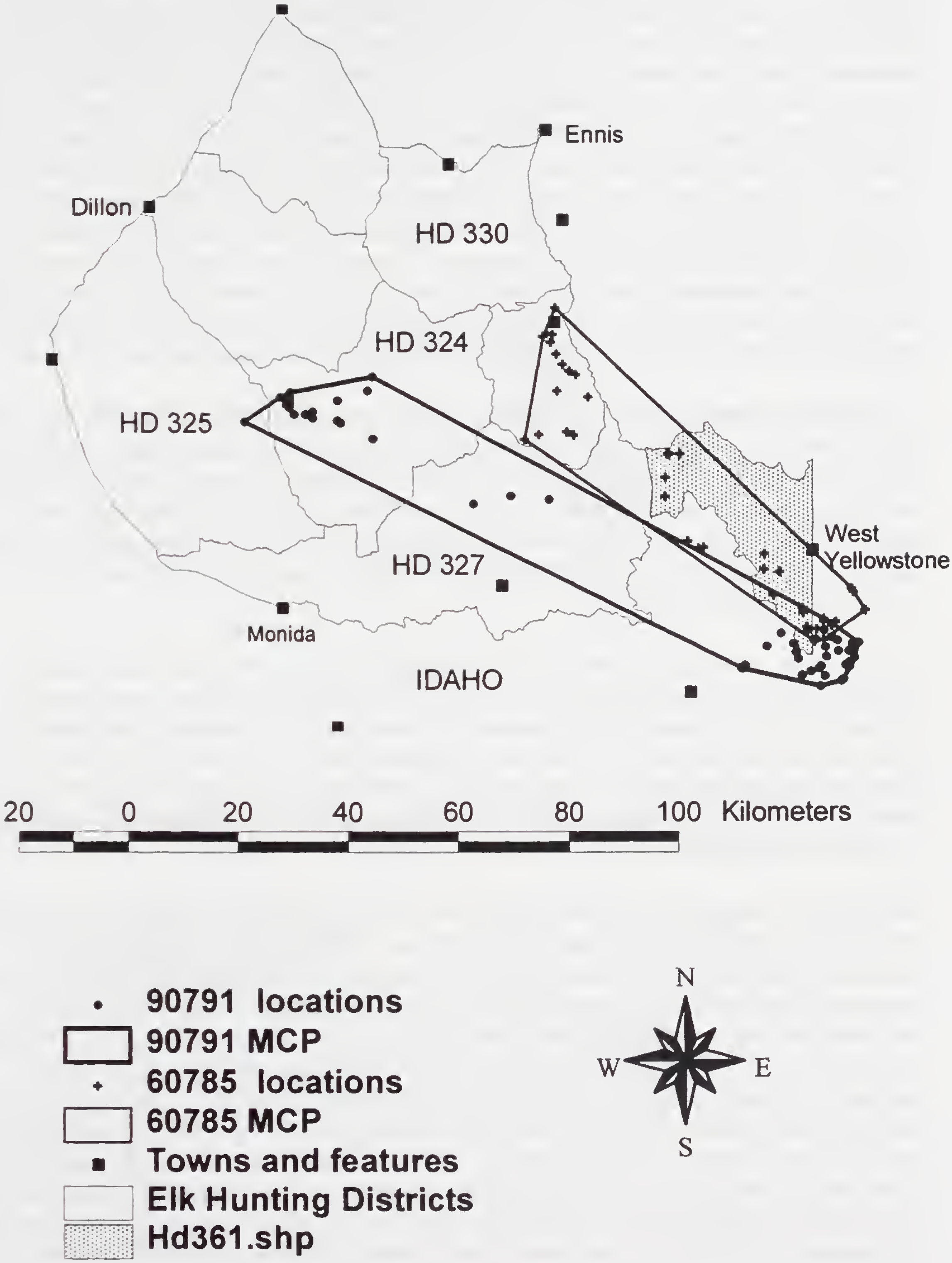


Figure 9.9. Examples of life home ranges of long distance migrant female elk.

Female 60785 used an area adjacent to 90791 during summer-autumn, but wintered primarily on the WCWMA (Fig. 9.9). Distance between winter and summer range was 80 km (50 mi) and MCP area was 1,219 km^2 (471 mi^2). She had more transition locations between winter and summer range than 90791, probably because of more timber cover in the intervening area. The locations midway between the WCWMA and summer range were winter locations at Sheep Creek during 1987 and 1988, however. Although using the same summer range each year, this female used the WCWMA during winter for 2 years, the Sheep Creek winter range for 2 years, and then the WCWMA again for at least 2 years. We relocated her for 5 years and she was harvested within her normal home range 6 years after the last radio relocation (11 years after marking). Some summer range did not have adequate winter range nearby and fill of this summer range was dependent on long distance migrants. Few elk made regular annual movements of the magnitude displayed in Figure 9.9, but many made annual movements intermediate to these.

We present examples of home ranges that encompassed movements intermediate (20 to 60 km between winter and summer range) to those described thus far in Figures 9.10 and 9.11. Most elk fit into the following categories: 1.) adjacent seasonal ranges, with high elevation summer ranges within 10 km of the winter range; 2.) migratory elk with summer and winter range separated by 20-60 km; 3.) long distance migrants with summer and winter range separated by 80-100 km and one or more open valleys and; 4.) wanderers, primarily bulls.

Intermediate and long distance migrants seldom had many relocation sites between winter and summer ranges (Fig. 9.9 – 9.12). Most transition locations were near the winter or summer ranges where adequate cover existed. The transition locations in Figure 9.12 all were during spring, on the way to summer range. It appeared that transition between seasonal ranges took place quickly, with little time spent in the intervening area. Because of the current rural nature of this landscape, movement of elk between mountain ranges with open intervening valleys did not appear to be impaired.

Most winter ranges were distinct, though elk on the immediately adjacent BTWMA and RLWMA and the WCWMA and Cherry-Morgan winter ranges did intermingle. On summer range there was considerable overlap among elk as widely separated as those wintering on the BTWMA and WCWMA (Fig. 9.13). Additional areas of overlap occurred for these populations and others (Figs. 9.4, 9.5, 9.6). Intermingling on summer range might be the mechanism for winter range switching, especially for younger animals. Although summer range fidelity appeared to be generally high, especially for older females, some shifting did occur. For female 50784 (Fig. 9.14), the southeast group of locations (red) was summer range as a newborn calf, the south-central group (green) was summer range as a 4-year-old, and the southwest group (blue) was summer range as a 5-year-old. Some overlap or transition locations occurred, however. The distance from the centers of the newborn locations to the 4-year-old locations was 9 km and the 4-year-old locations to the 5-year-old locations was 14 km. This was a total distance of 23 km (14 miles) between her summer home range as a newborn and her summer home range as a 5-year-old. Although all her summer ranges overlapped areas used by BTWMA elk during summer, she wintered on the WCWMA throughout the 5-year period.

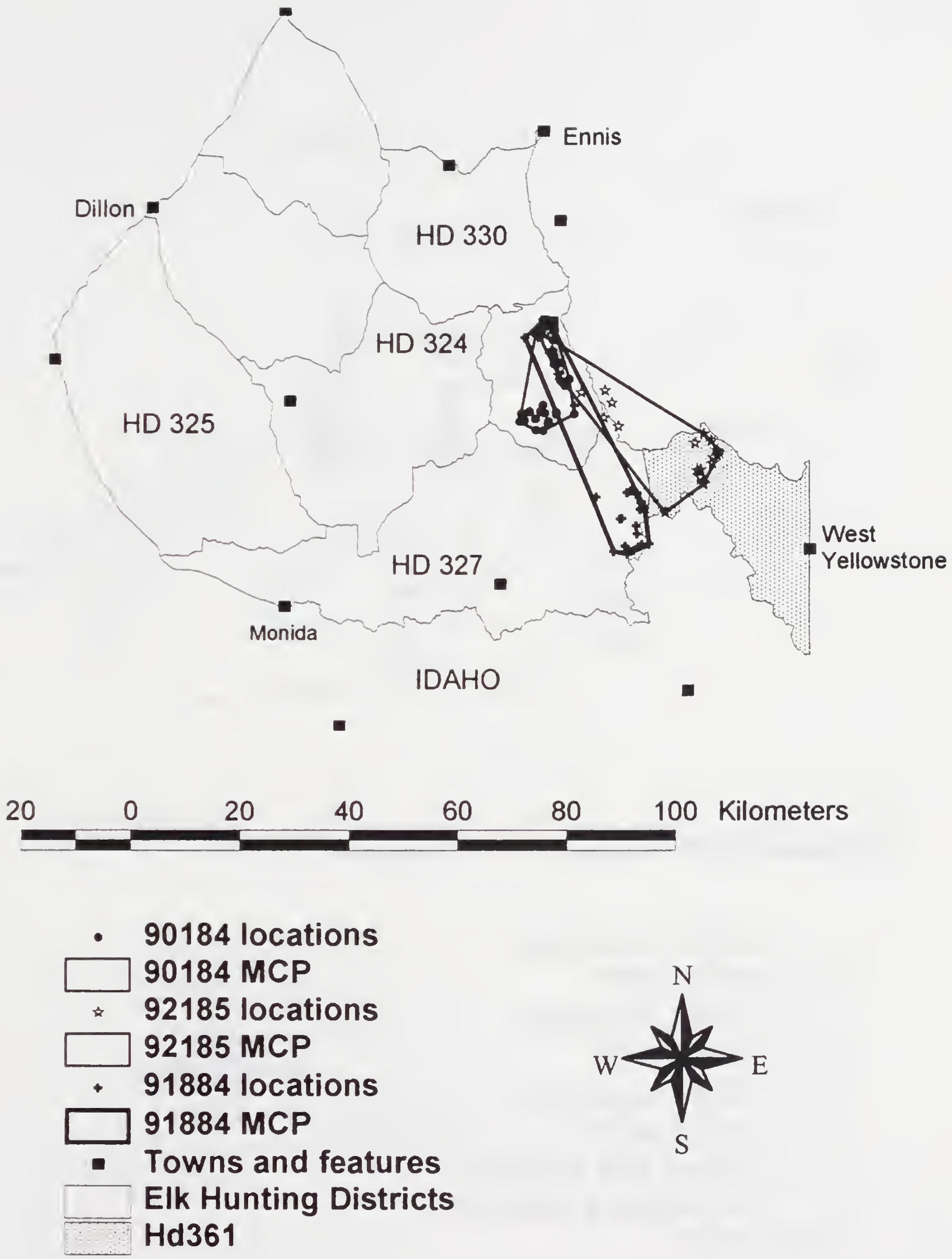


Figure 9.10. Life home ranges of 3 female elk that wintered on the Wall Creek Wildlife Management Area and had intermediate distance movements to summer range.

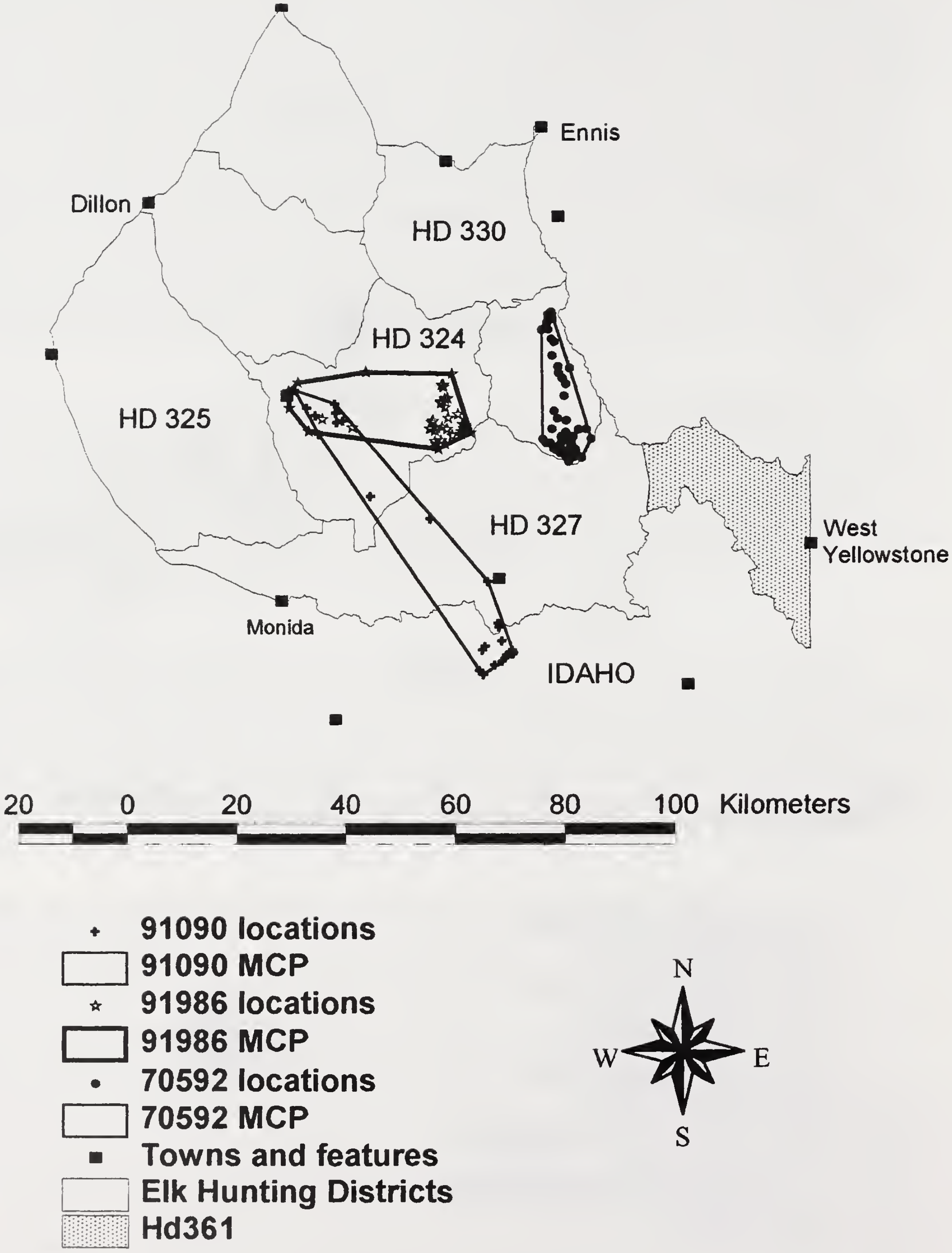


Figure 9.11. Additional examples of life home ranges for 3 female elk with intermediate distance movements between winter and summer range.

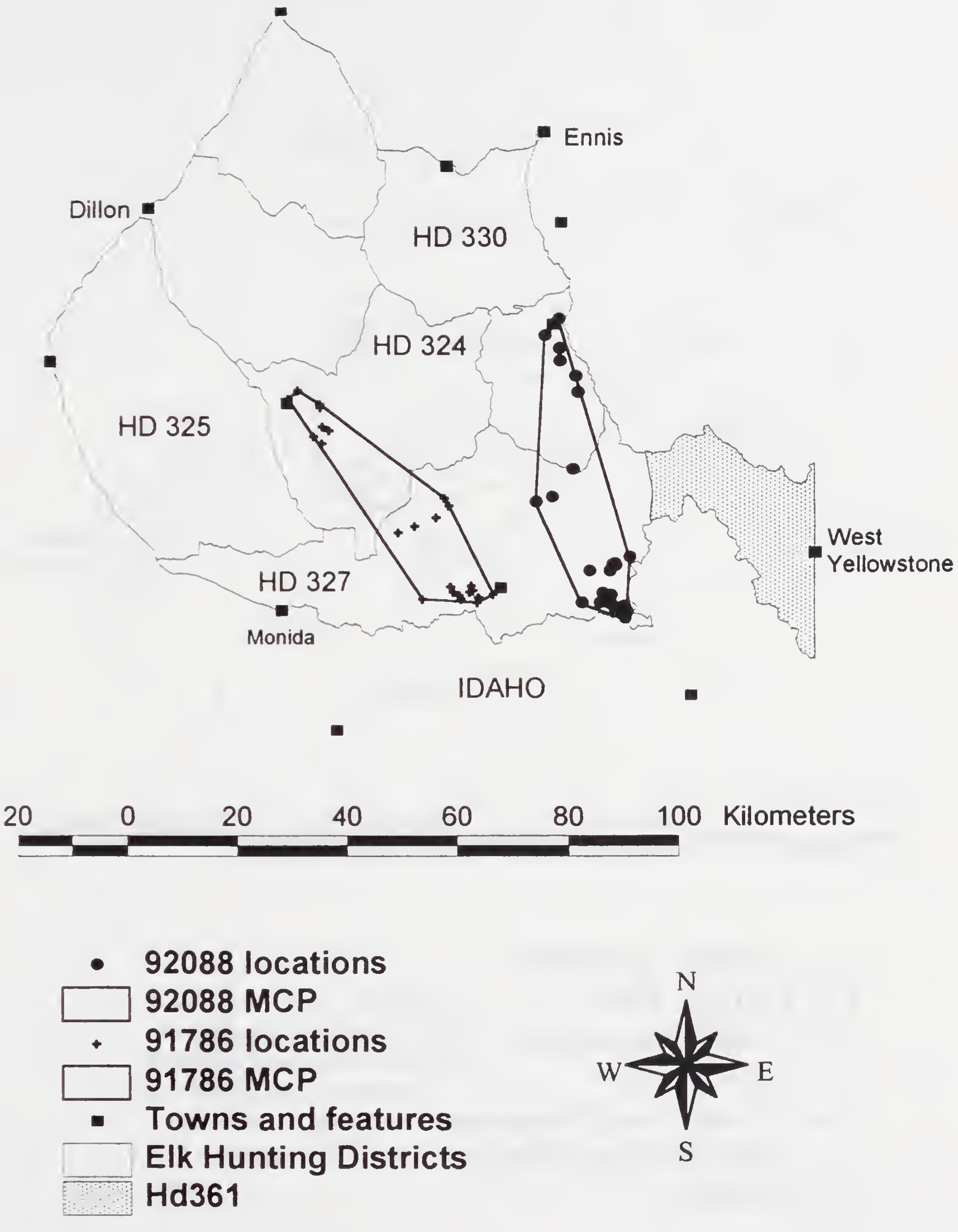


Figure 9.12. Examples of life home ranges for 2 female elk with spring transition locations between winter and summer range.

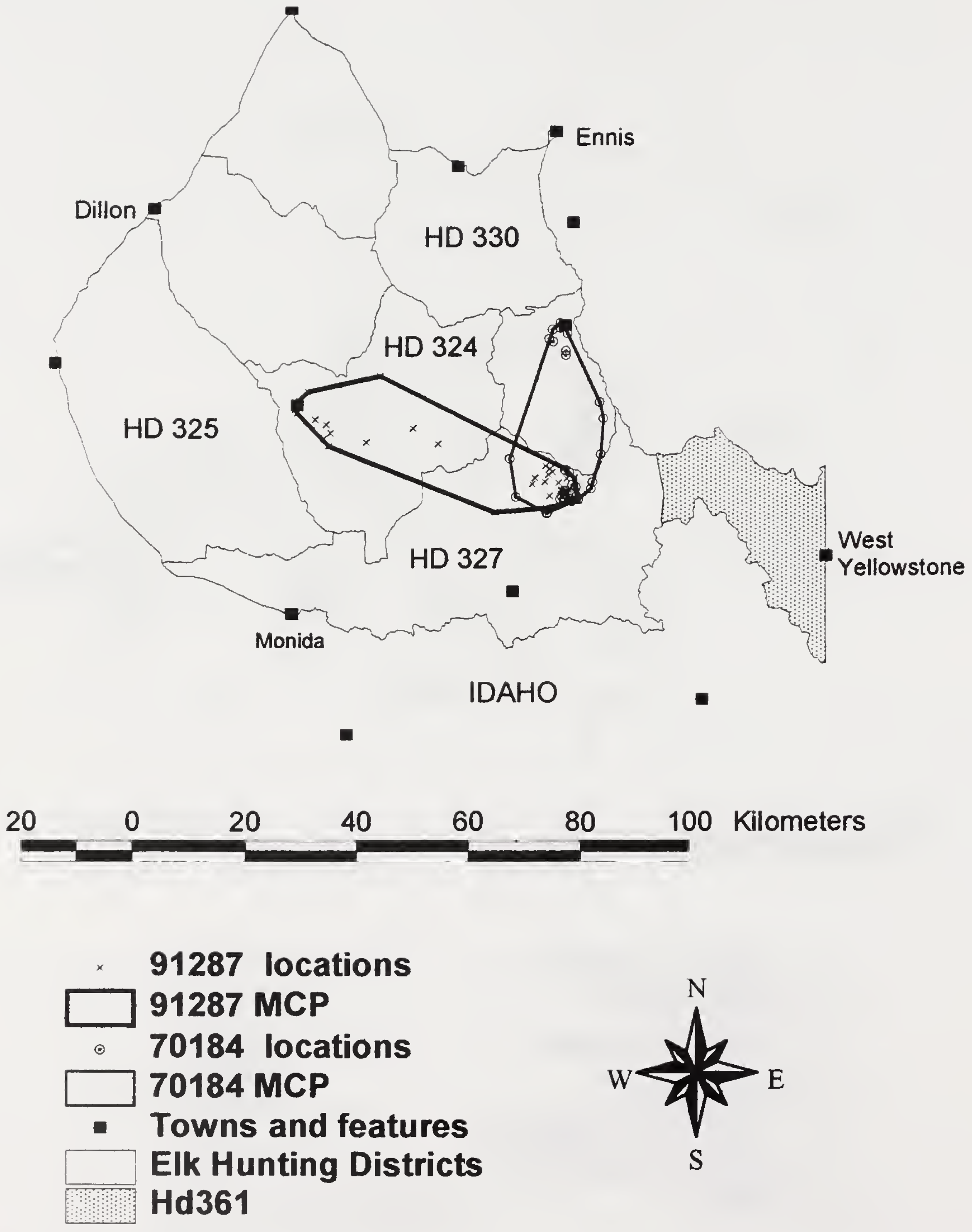


Figure 9.13. Example of overlapping summer ranges for female elk using the Blacktail Wildlife Management Area and Wall Creek Wildlife Management Area winter ranges.

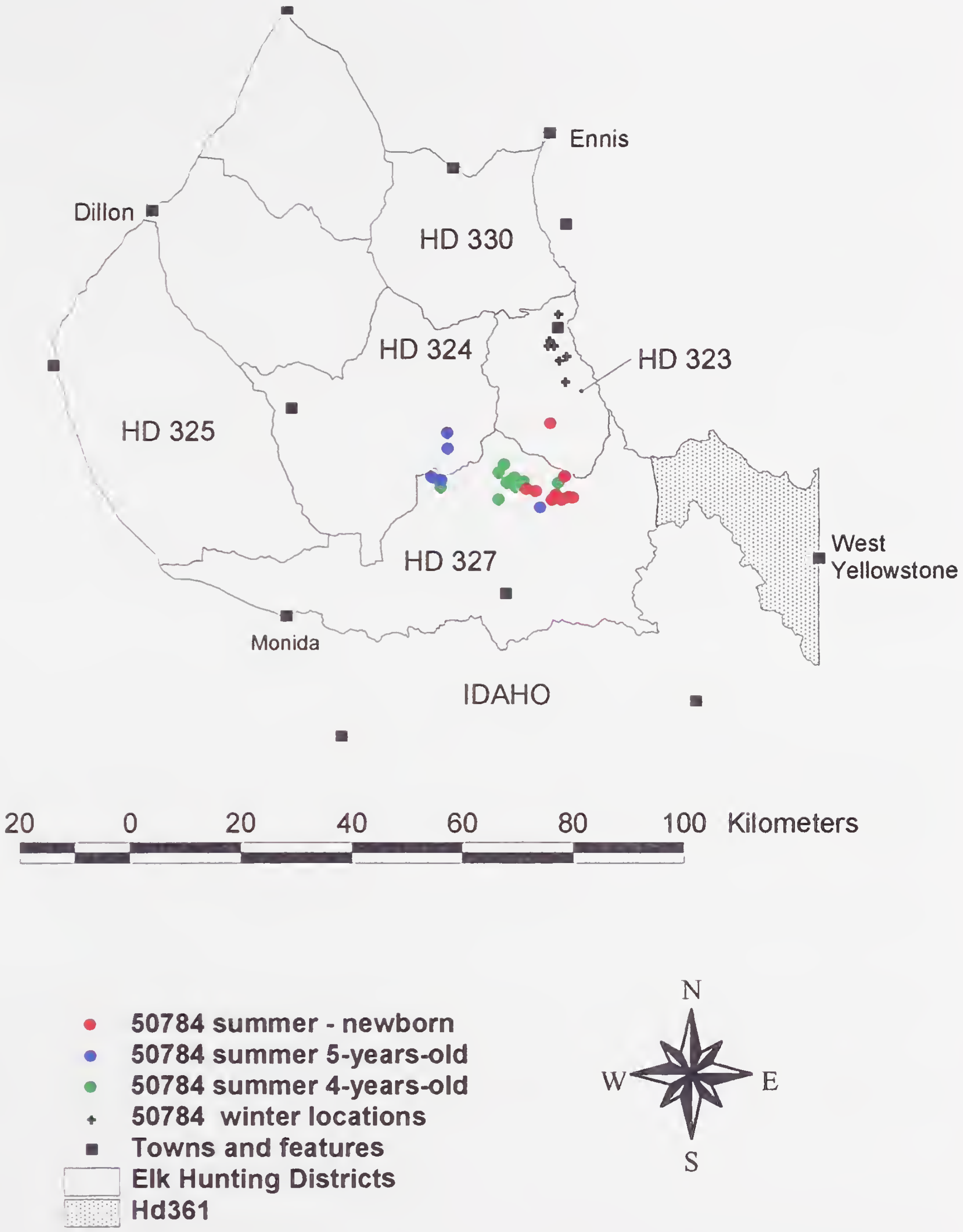


Figure 9.14. An example of summer range location changing over the life of a female elk (50784) from birth to 5-years-old.

Home Range Fidelity

We examined movements of radiocollared elk to determine fidelity to winter and summer range by age. Winter range determinations were simple for the most part, but required some categorization. We made separate determinations for fidelity excluding those animals that moved to immediately adjacent winter ranges (WCWMA – Cherry-Morgan and BTWMA – Robb-Ledford). We also made separate determinations that additionally excluded elk that remained on summer-autumn/transition range during mild winters. These areas included the North and South Centennials, the upper Ruby Valley, and the West Fork of the Madison River. Some of the switching of ranges that occurred was not permanent; the elk switched back in a subsequent year. When that occurred, we recorded them as moving again at their current age. Determination of changing of summer ranges was more arbitrary. We used no fixed distance measure, but generally relied on a clear separation of location clusters such as portrayed in Figure 9.14.

Males were more likely to change both winter and summer ranges than females, and young elk were more likely to move than older elk (Table 9.4). It appeared that for younger elk, changes of summer range were more common than changes of winter range, especially when the effects of immediately adjacent ranges and winter severity were taken into account (Table 9.4).

There were no differences (χ^2, all $P > 0.17$) in rates of switching winter ranges for males and females between the calf and yearling years. During the yearling to 2-year-old period (Table 9.4), males switched winter ranges at a higher rate than females (χ^2, all $P < 0.002$). This difference remained significant during the 2 to 3-year-old period (χ^2, all $P < 0.02$). Our sample of males ≥ 3 years old was too small for comparison with females. Females ≥ 3 years old changed winter ranges at very low rates (Table 9.4).

Table 9.4. Winter and summer range fidelity of male and female elk by age category, expressed as percent of radiocollared sample that switched ranges.

Sample	Winter Range							
	Calf to Yearling		Yearling to 2 ½ years		2 ½ to 3 ½ years		≥3 ½ years	
	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
All	36.8(38)[a]	28.7(157)	16.1(62)	44.2(43)	20.3(69)	55.6(9)	8.9(338)	0(1)
Excl. Adj. WR[b]	17.2(29)	20.6(141)	10.3(58)	36.8(38)	12.7(63)	50.0(8)	4.6(323)	0(1)
Excl. mild WI[c]	11.1(27)	17.6(136)	10.3(58)	36.8(38)	9.8(61)	50.0(8)	2.2(315)	0(1)
	Summer Range							
All	33.3(12)	46.2(13)	37.8(37)	56.5(138)	8.2(61)	26.1(23)	2.1(375)	33.3(3)

[a] Percent of sample that switched ranges (sample size).

[b] Excluding elk that switched between immediately adjacent winter ranges (BTWMA and RLWMA, WCWMA and Cherry-Morgan).

[c] Also excluding elk that stayed near summer-autumn range during mild winters.

For females, different rates of switching winter ranges among age classes were not significant from calf through 3 years old (χ^2_1, all $P > 0.36$). An exception occurred for the difference between calf to yearling and yearling to 2-year-old ($\chi^2_1 = 5.5$, $P = 0.02$) when elk that moved to immediately adjacent ranges or did not return to their normal winter range during mild winters were not excluded. The differences among females ≥3 years old and all younger age classes were significant (χ^2_1, all $P < 0.01$). Exceptions may have occurred for the yearling to 2-year-old class when all were included or those from immediately adjacent ranges were excluded (χ^2_1, both $P = 0.08$). Sample size may have been a problem for those comparisons. Winter range switching rates of females for the calf to 3-year-old category combined were 22.5%, 12.7%, and 10.3% for all, adjacent winter ranges, and mild winter categories, respectively. The same comparison for males was 33.0%, 25.1%, and 23.1%. These differences were significant (χ^2_1, all $P < 0.02$). Because of sample size, only comparison of differences in males between calf to yearling and yearling to 2 year old were possible. Males changed winter ranges at a greater rate from their yearling to 2-year-old year than their calf to yearling year (χ^2_1, all $P < 0.05$). Although samples were small, the rate of switching apparently did not decline with age for males as it did for females (Table 9.4). Males changed winter ranges at higher rates than females, females ≥3-years-old had high fidelity to winter range (91.1 – 97.8%), and about half of males aged 2 and 3 years old changed winter ranges each year. From calves to 3 years old, females changed winter ranges at rates that were relatively high (10 – 37 %).

Females and males did not change areas of use between their newborn summer and yearling summer at different rates ($\chi^2_1 = 0.43$, $P = 0.51$); both rates were relatively high (Table 9.4). Males did change areas of summer use at greater rates than females between yearling and 2 years old ($\chi^2_1 = 4.08$, $P = 0.04$) and 2 years old and 3 years old ($\chi^2_1 = 4.70$, $P = 0.03$). For females, differences in rates did not occur between newborns to yearlings and yearlings to 2 year olds ($\chi^2_1 = 0.08$, $P = 0.78$). Rates of switching differed between these 2 categories and all older females (χ^2_1, all $P < 0.02$); the rate of changing summer range declined substantially after 2 years old (Table 9.4). Females changed summer ranges more often than winter ranges from calf through 2 years old but at a lesser rate between 2 and 3 years old and at similar rates at ≥3 years old. Similar to females, rates of changing areas of summer use was not different for males between newborn to yearling and yearling to 2 years old ($\chi^2_1 = 0.52$, $P = 0.47$). The rate of changing areas of summer use were substantially lower ($\chi^2_1 = 7.32$, $P = 0.007$) for the combined category of males >2 years old than for males <2 years old but both rates were higher than for the same categories of females ($\chi^2_1 = 5.29$, $P = 0.02$).

For elk calves through 2 years old, both females and males changed areas of summer use at greater rates than areas of winter use. These rates of switching ranges were reduced substantially for females >2 years old both for summer and winter. Sample sizes for older males were too small to assess whether their rate of switching ranges changed with age.

Emigration and Immigration

After removing from the sample all marked elk that we knew to have died before the age of one, 303 males and 598 females remained as potential emigrants. Use of this sample might provide underestimates because we included elk marked with only neckbands and/or eartags. Some may have died without our knowledge or may have emigrated and were not shot and reported or otherwise observed. However, the possibility of overestimates of emigration rate occurred because some elk we classified as emigrants based on location of kill may have returned to the Gravelly-Snowcrest population if not harvested. On balance, we believe that emigration rates we report are relatively accurate.

We classified 28 males (9.2%) and 19 females (3.2%) as emigrants from the Gravelly-Snowcrest population. Additionally, telemetry contact was lost with 18 males during June and July. Based on our other information (Table 7.11), at least 5 of these were likely emigrants. Thus emigration rate of males could have been 10.9%. Similarly, we suspected, but could not verify, that at least 2–4 additional females emigrated. Even if 4 additional females emigrated, the rate would have been no more than 3.8%. If not balanced by immigration, these emigration rates must be considered as mortality in population calculations and models. We did not know exact ages at emigration for many in the sample, but males appeared most likely to emigrate at 2 years old and females at either 1 or 2 years old. These rates were higher than most rates reported for other areas, but our study involved more intensive work over a longer series of years than other studies and was more likely to eventually detect emigrants. Also, it is possible that high emigration rates may have reflected relatively high population density. Emigration rates of 3.9% for males and 1.6% for females were reported for the Sand Creek, Idaho population (Brown 1985, Hughbanks 1993, and Hughbanks, pers. comm.). For the Elkhorn Mountain population, DeSimone and Vore (1992) reported emigration rates of 3.2% for bulls and 0.7% for females. Edge et al (1986) reported that 1.7–3.1% of cow elk emigrated from their herd range in Chamberlain Creek in western Montana. Known endpoints of emigration for females (Fig. 9.15) and males (Figs. 9.16 and 9.17) indicated a tendency for movements to the south and southeast. This resulted in more movement to Idaho, YNP, and Wyoming than to other Montana hunting districts.

Immigration to the Gravelly-Snowcrest population was more difficult to document but did occur. Known starting and endpoints of immigration to the Gravelly-Snowcrest Mountains for females (Fig. 9.18) and males (Fig. 9.19) represent only a few surrounding areas where samples of elk have been marked. With the exception of the Sand Creek population in Idaho, information on immigration is not of equal intensity as that on emigration and represents the minimal level of immigration. Brown (1985) and Hughbanks (1993, and pers. comm.) documented 9 (2.9%) of 307 males from the Sand Creek, Idaho population that moved to the Gravelly-Snowcrest population. They also documented 7 (1.2%) of 572 females that were immigrants to the Gravelly-Snowcrest population. Four (7.1%) of 56 2-year-old males from the Flying D population in HD 311 moved to Gravelly-Snowcrest population segments (G. Taylor, MFWP files). Two (0.5%) of 426 newborn calves marked in the Gallatin drainage between 1938 and 1962 moved to the Gravelly Mountains. One was a male and one a female. Because many of

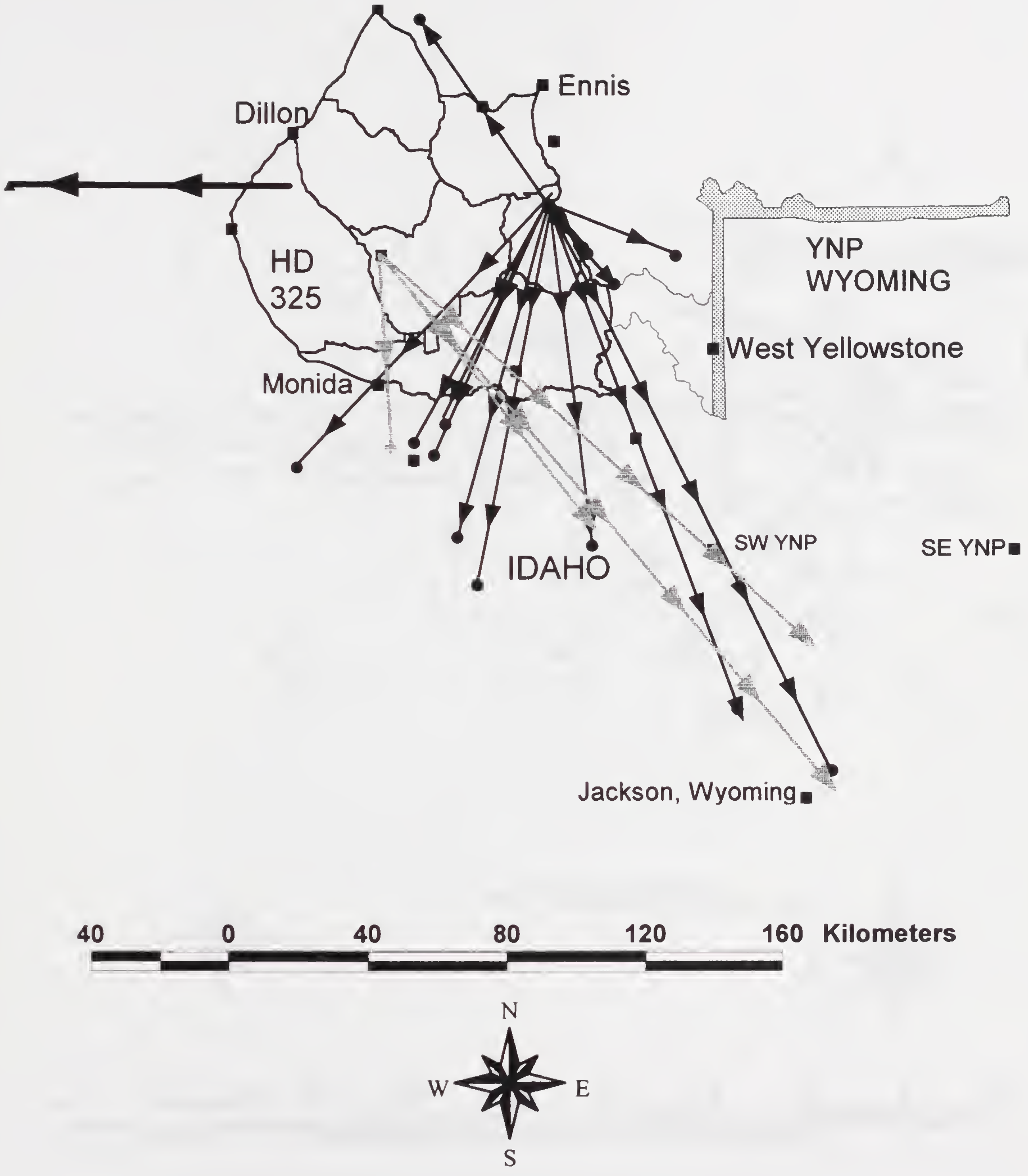


Figure 9.15. Emigration of female elk from the Gravelly-Snowcrest Mountains.

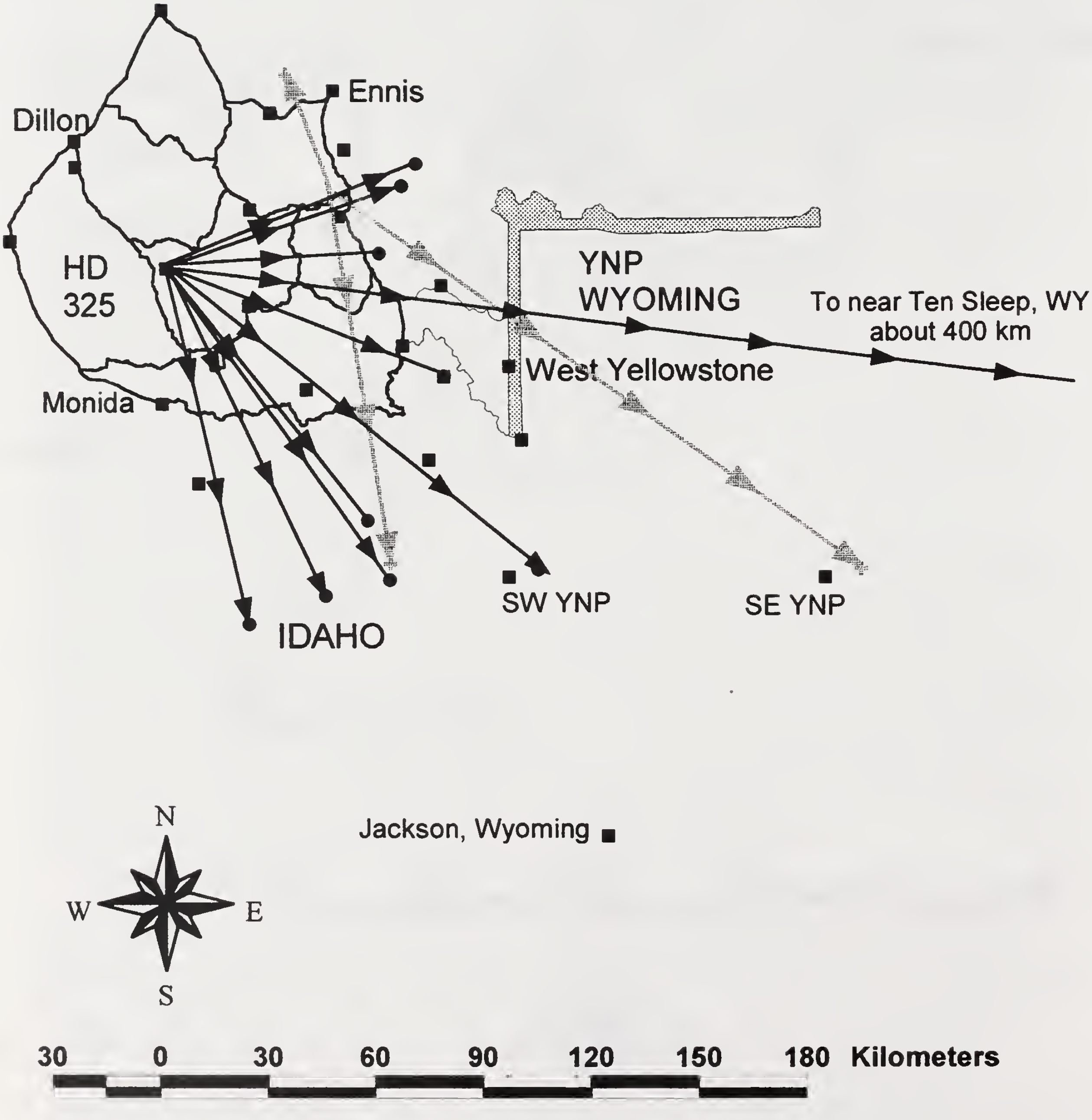


Figure 9.16. Emigration of male elk captured on the BTWMA and Cherry-Morgan winter ranges.

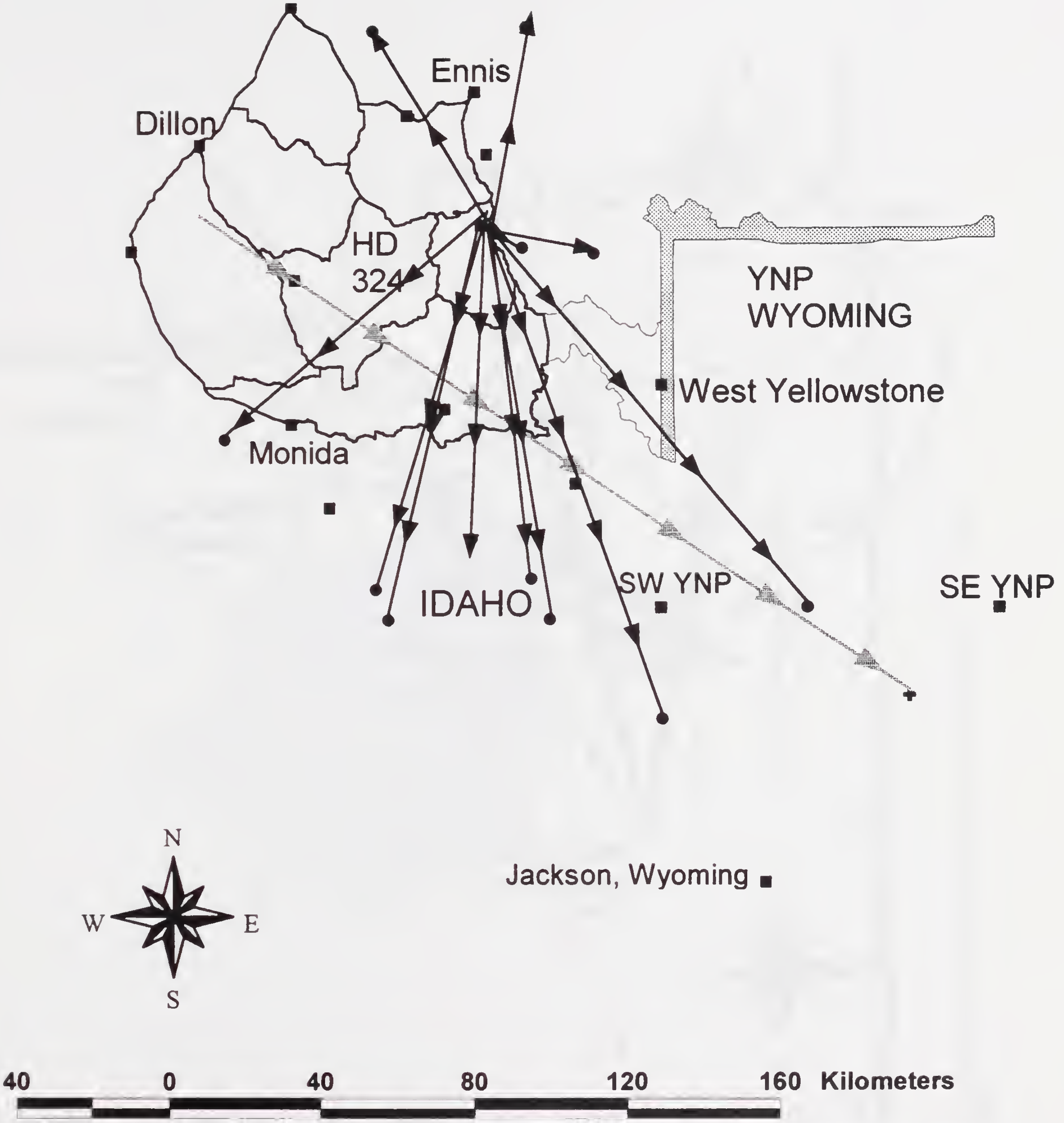


Figure 9.17. Emigration of male elk captured on the WCWMA and Blacktail Ridge winter ranges.

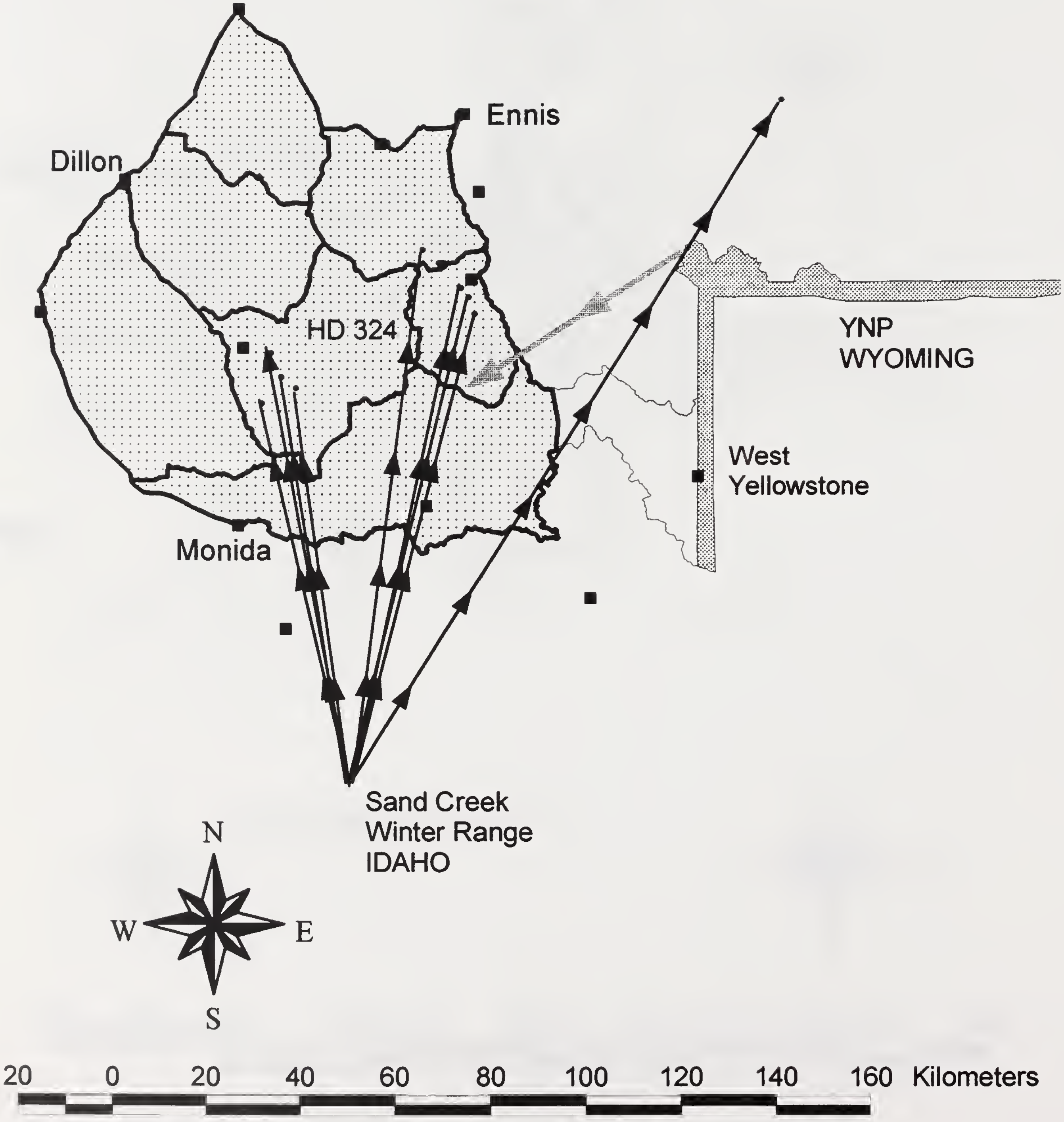


Figure 9.18. Immigration of female elk to the Gravelly-Snowcrest Mountains.

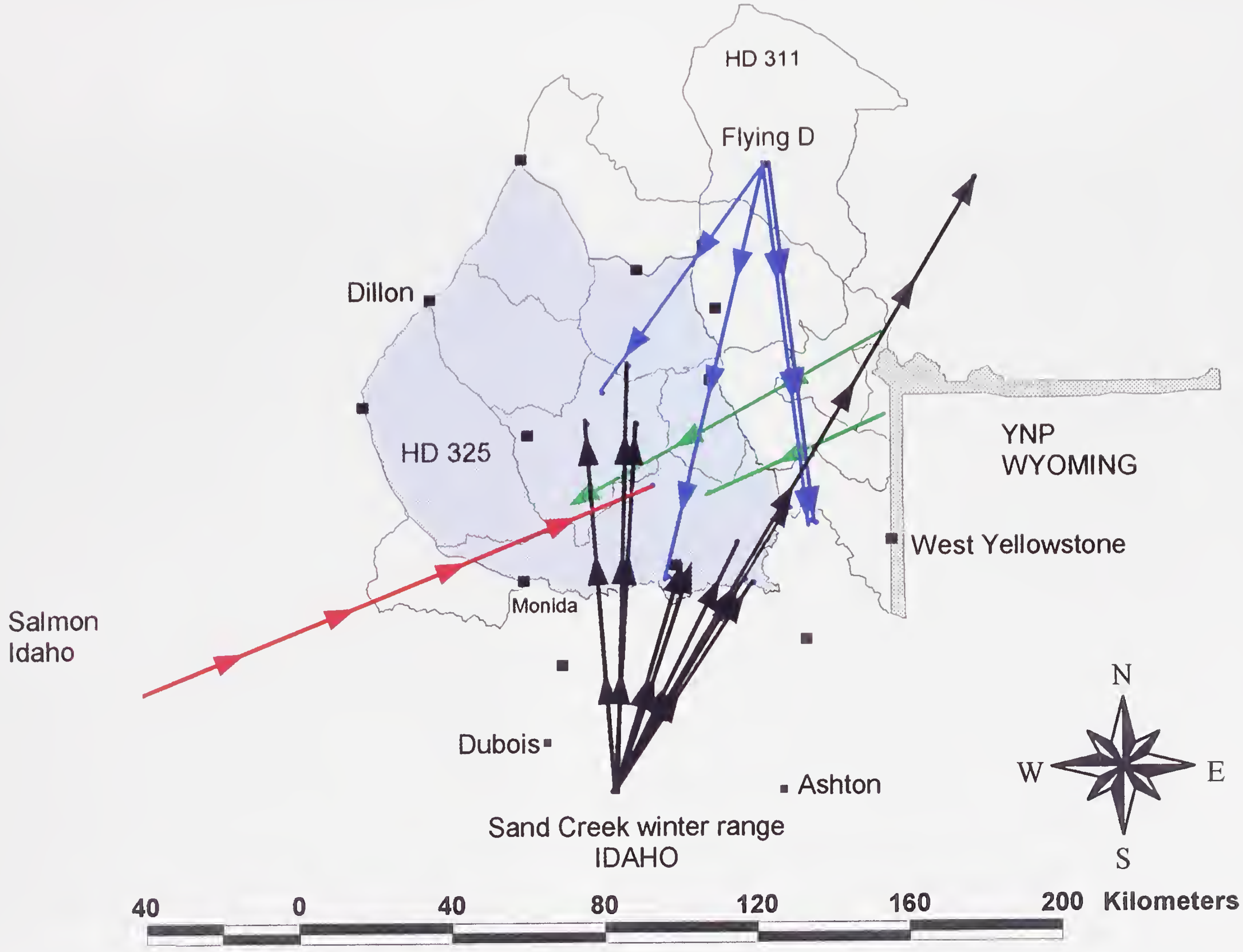


Figure 9.19. Immigration of male elk to the Gravelly-Snowcrest Mountains.

these calves likely died prior to reaching age of emigration, this reported rate is minimal. Only 1 (0.3%) of 338 adults (unknown sex composition) marked in the Gallatin drainage in 1962 and 1965 moved to the Snowcrest Mountains (MFWP files). More recently, none of 18 females and 1 male marked in the Gallatin during 1976-1984 moved to the Gravelly-Snowcrest area. During the same period, none of 4 males marked in the Madison drainage moved to the Gravelly-Snowcrest area. One of 17 females marked in the Madison moved from the Bear Creek Wildlife Management Area to the WCWMA for a 2-3 week period, but then moved back to Bear Creek. Excluding animals known to have died before 1 year of age, none of 6 males and 12 females marked in the Tobacco Root Mountains, or 2 males and 5 females marked in the Ruby Mountains moved to the Gravelly-Snowcrest Mountains (B. Brannon, pers. comm.). None of 3 females marked in HD 300 moved to the Gravelly-Snowcrest Mountains (J. Peterson, pers. comm.). A bull marked near Salmon, Idaho moved to the Snowcrest Mountains. In October 1968, a 2-year-old bull was shot in Standard Creek (Gravellys) that had been marked on the National Elk Refuge near Jackson, Wyoming.

Our information was not sufficient to estimate whether emigration and immigration was balanced in numbers. However, it was sufficient to indicate that interchange occurred among the Gravelly-Snowcrest elk population and elk populations in Idaho, YNP, Grand Teton National Park, the National Elk Refuge, surrounding areas of Wyoming, and most surrounding hunting districts of Montana. This interchange has implications with regard to disease transmission, genetic interchange/diversity, and population linkage/travel corridors/habitat connectivity.

Currently, the Gravelly-Snowcrest elk population has a low seroprevalence (0.4%) of brucellosis. Population interchange occurs with feedground populations in northwestern Wyoming that have 16-50% seroprevalence (Herriges et al. 1992). We do not know the method or source of infection/exposure for the 4 elk in the WCWMA population with seropositive reactions for brucellosis. However, the potential that up to 30 WCWMA elk may be seropositive for brucellosis did not indicate an infection rate different than could have been produced solely by immigration of seropositive elk.

If emigration and immigration rates are similar, annual genetic interchange of about 10% for males and 3% for females occurs. Intrapopulation dispersal (emigration/immigration) among herd ranges and seasonal ranges was higher, averaging 18-50% for males and 10-37% for young females (Table 9.4). These levels of inter- and intrapopulation movements should be more than adequate to naturally maintain genetic diversity. The observed levels of emigration/immigration also served to contribute to and maintain habitat fill, even when summer range was at long distances from winter range.

For most of the Gravelly Landscape Analysis Area, housing developments are minimal, major highways exist only at the outside boundaries, and open valleys retain a rural character. There was no evidence that the current level of residential/commercial development affected movements of elk. Current highway systems, residential development, or rural open valleys did not impede movements of elk from the Gravelly-Snowcrest Mountains, nor immigration to the Gravelly-Snowcrest Mountains. We could not delineate definite travel corridors, however elk temporarily used timbered cover within open valleys in their movements. These small patches of cover were not sufficient to hold elk during hunting seasons, but were important as temporary cover during transition at times when disturbance was low.

CHAPTER 10

HABITAT USE

Roads and Forested Habitat

Because this study was not designed as a habitat use study, we limited our examination of the telemetry data to macro habitat analysis and most specifically to habitat questions related to hunting. Our first level of analysis compared distribution of bull and antlerless kill locations and locations of living, radiocollared elk during the general hunting season among the following 4 categories of habitat: < ½ mi from a road and forested (0.80 km, English equivalent used to relate to original paper); <½ mi from a road and non-forested; ≥ ½ mi from a road and forested and; ≥ ½ mi from a road and non-forested. Both the road and forest cover data were taken from files prepared by the Gravelly Landscape Analysis Team (USFS and others). Forest and non-forest types were at a broad scale; forested did not necessarily mean that it provided elk hiding cover. Hunters reported kill locations and they were not precise but should represent a statistical balance for our analyses. Kill and live locations were not necessarily independent. An elk could provide several live locations and be shot later in the hunting season, providing a kill location then.

Kill locations for bull elk were distributed differently than kill locations for antlerless elk by habitat category (Table 10.1, $\chi^2_3 = 7.70$, $P = 0.05$). Kill locations of bulls were in forested habitat ≥ ½ mile from a road more frequently than kill locations of antlerless elk (67% of χ^2 value). Locations of living bulls and antlerless elk were not distributed differently among habitat categories ($\chi^2_3 = 1.83$, $P = 0.61$). This suggested that hunters were willing to hunt in forested habitat and further from a road to harvest bull elk compared to antlerless elk. Kill locations of bulls were distributed differently than locations of living bulls ($\chi^2_3 = 124.7$, $P < 0.0001$). A disproportionate proportion of kill locations within non-forested habitat < ½ mile from a road contributed 77 percent of χ^2 value. Results were similar for antlerless elk ($\chi^2_3 = 224.9$, $P < 0.0001$). A disproportionate proportion of kill locations within non-forested habitat < ½ mile from a road contributed 70 percent of χ^2 value. Thus, a disproportionate number of kills of both bulls and antlerless elk occurred in open habitat within ½ mile of a road.

Table 10.1. Raw numbers of kill locations by habitat category for marked elk and telemetry locations of living elk during the general hunting season (20 Oct. – 1 Dec.), 1984-1996, Gravelly-Snowcrest Mountains.

		< ½ mile from road		≥ ½ mile from road		
		Forested	Non-forested	Forested	Non-forested	Total
Bull	Kill	12	41	46	39	138
	Live	24	8	60	20	112
Antlerless	Kill	34	83	63	82	262
	Live	136	69	430	149	784
Total		206	201	599	290	1296

We combined locations to test for distribution in just forested vs non-forested and just < ½ mi and ≥ ½ mi from road categories. Kill locations ($\chi^2_1 = 0.95$, $P = 0.33$) and live locations ($\chi^2_1 = 0.39$, $P = 0.53$) were not distributed differently for bulls and antlerless elk between forested and non-forested types. For the sexes combined, kill locations were disproportionately distributed in non-forest types ($\chi^2_1 = 134.2$, $P < 0.0001$). Similarly, kill locations ($\chi^2_1 = 1.45$, $P = 0.23$) and live locations ($\chi^2_1 = 0.30$, $P = 0.59$) were not distributed differently for bulls and antlerless elk between areas < ½ mi and ≥ ½ mi from a road. For antlerless elk, kill and live locations were distributed differently ($\chi^2_1 = 31.6$, $P < 0.001$), with kill locations disproportionately closer to roads. For bulls, the difference was not significant, ($\chi^2_1 = 2.66$, $P = 0.10$), though smaller sample size may have contributed to this lack of difference. The trend for bulls was for kill locations to be disproportionately close to a road. The lesser difference as compared to antlerless elk may have reflected the willingness of hunters to hunt harder for bulls.

We further examined the influence of roads on elk kill by using the GIS layer of road density category prepared by the Gravelly Landscape Analysis Team. For this layer, areas were delineated as: No Roads; Low Roads [0.1-1 miles of road/ mi^2 (0.062-0.62 km/km^2, English system used to relate to USFS standards)]; Medium Roads (1.1-2 miles of road/ mi^2) and; High Roads (> 2 miles of road/ mi^2). For the entire analysis area, percentages within the categories were 17.1, 30.7, 36.2, and 16.0 percent, respectively. For individual category analyses, we clipped the area for availability of roads to that within the polygon of the kill/live and bull/antlerless locations. This was a conservative approach that eliminated much of the high road density category in non-habitat for elk.

Kill and live locations were not distributed differently among road density categories for bulls ($\chi^2_3 = 6.46$, $P = 0.09$), but were distributed differently for antlerless elk ($\chi^2_3 = 19.78$, $P = 0.0002$). Antlerless kill locations were disproportionately associated with high road density areas (43% of Chi-square value) and negatively associated with no road areas (39% of Chi-square value) compared to live locations. Compared to availability, kill locations of bulls were positively associated with no road areas (25% of Chi-square variation) and medium road density areas (28% of variation) and negatively associated with high road density areas (30% of variation) (Table 10.2, $\chi^2_3 = 20.92$, $P = 0.0001$). Locations of living bulls were positively associated (45% of Chi-square value) with no road areas and negatively associated with high road areas (52% of Chi-square value). Antlerless kill was not distributed differently than in proportion to availability relative to road density category (Table 10.2). Locations of living antlerless elk were positively associated ($\chi^2_3 = 96.5$, $P < 0.0001$) with no road areas (56% of Chi-square value) and negatively associated with high road areas (43% of Chi-square value).

Table 10.2. Distribution of bull and antlerless kill locations and locations of live elk by road density category, Gravelly-Snowcrest mountains, 1984-1996.

	Road Density Category[a]				Statistics
	No Roads	Low Roads	Medium Roads	High Roads	
Bull kill	29(21.0)[b]	36(26.1)	59(42.8)	14(10.1)	$\chi^2_3 = 20.9$
Availability	(19.7)	(31.5)	35.3)	(13.5)	P = 0.0001
Living Bulls[c]	25(22.7)	38(34.6)	38(34.6)	9(8.2)	$\chi^2_3 = 14.8$
Availability	(20.2)	(30.6)	(35.3)	(13.9)	P = 0.002
Antlerless kill[c]	40(15.4)	87(33.5)	96(36.9)	37(14.2)	$\chi^2_3 = 6.2$
Availability	(18.2)	(30.5)	(35.3)	(15.5)	P = 0.10
Living Antlerless	186(23.8)	284(36.3)	243(31.0)	70(8.9)	$\chi^2_3 = 96.5$
Availability	(19.1)	(31.4)	(35.5)	(14.0)	P = 0.0001

[a] No Roads = no roads/mi^2, low roads = 0.1-1.0 miles of roads/ mi^2, medium roads = 1.1-2.0 miles of roads/mi^2, high roads = > 2.0 miles of road/mi^2.

[b] Number of locations (percent of locations).

[c] Two outlier locations excluded from polygon used to determine road availability because inclusion would substantially increase the amount of roaded, non-elk habitat.

Although this measure did not seem as sensitive as the road buffer measurement, it indicated the same conclusion. Bull kill occurred further from roads, on average, than antlerless kill and kill of both bulls and antlerless elk occurred in high road-density areas more frequently than would be expected based on proportional distribution. Locations of living elk were disproportionately associated with forested cover and greater distances from roads or areas with fewer roads during hunting season.

Others, including Christensen et al. (1993), Unsworth et al. (1998), and Hurley (1994) reported findings similar to ours regarding elk harvest and roads. However, Christensen et al (1993) noted that reducing the amount of roads was more effective in reducing elk harvest in areas of heavy cover than in areas of sparse cover and gentle terrain.

The Hillis Paradigm (Hillis et al. 1991) suggested that security areas for elk should be ≥ 250 acres (100 ha), ≥1/2 mile from an open road, and should comprise ≥ 30% of a valid analysis unit. These criteria were considered minimal and several caveats were discussed. For example, if cover is limited and terrain is gentle, a distance >one half mile from a road may be necessary to provide security. Similarly, although closing existing roads may provide security, even closed roads in a security block may reduce its effectiveness compared to non-roaded areas. Also, open roads elevationally above and below the security block may encourage hunter walk-throughs.

We examined the total study area and the portion within the forest boundary to determine amount and distribution of elk security cover present. However, we could not determine which areas of cover actually provided elk security based on current mapping. We used all timber cover to represent elk security cover in this analysis, but future refinements with cover density will necessarily reduce elk security cover to less than that considered here. Similarly, adjustments for road placement, closed roads, and ruggedness of terrain should be made. Thus, our analysis does not provide a strict test of the Hillis Paradigm specifications (easier to meet criteria in our analysis). For the entire GLAA, only 10.5% met minimal Hillis Paradigm criteria (Table 10.3). Of the area within Forest boundaries, 26.7% met the criteria (Table 10.3), still less than the minimum 30% recommended. Hunting district 323 was the only HD to individually meet minimal criteria at 31.2% overall and 38.3% within Forest boundaries. Any timber harvest would further reduce elk security in this cover deficient area, especially given the fact that some areas classified as timber cover in this analysis do not provide elk security. For some areas, even a reduction in open roads will not result in 30% of an analysis area providing elk security cover. Reduction in open roads must also be balanced with the necessity of achieving adequate antlerless harvest.

Table 10.3. Number and size of cover blocks and percent of Hunting Districts and USFS ownership that meet Hillis Paradigm criteria or larger block criteria, Gravelly-Snowcrest Mountains.

		Security Cover Block Size		
Hunting District	HD size[a] (USFS)	>100 ha (247 acres)	> 260 ha (642 acres)	> 1000 ha (2470 acres)
323	492 (398)	4 – 153.4 – 31.2[b] 4 – 152.5 - 38.3[c]	2 – 151.1 – 30.7 2 – 150.2 – 37.7	2 – 151.1 – 30.7 2 – 150.2 – 37.7
324	1219 (705)	22 – 202.7 – 16.6 19 - 182.8 – 25.9	14 – 188.4 – 15.4 11 – 169.6 – 24.1	5 – 140.3 – 11.5 5 – 131.9 – 18.7
325	1652 (0)	7 – 61.7 – 3.7 0 – 0 - 0	3 – 49.4 – 3.0 0 – 0 - 0	1 – 43.7 – 2.6 0 – 0 - 0
326	1048 (0)	2 – 8.3 – 0.8 0 – 0 - 0	0 – 0 – 0 0 – 0 - 0	0 – 0 – 0 0 – 0 - 0
327	1826 (504)	19 – 236.5 – 12.9 9 – 105.0 – 20.9	9 – 220.2 – 12.1 4 – 96.0 – 19.1	4 – 200.3 – 11.0 2 – 87.0 – 17.3
330	847 (283)	11 – 80.4 – 9.5 10 – 64.7 – 22.9	9 – 76.8 – 9.1 8 – 61.7 – 21.8	3 – 45.9 – 5.4 2 – 25.1 – 8.9
Total	7084 (1890)	65 – 743.0 – 10.5 42 – 505.0 – 26.7	37 – 685.9 – 9.7 25 – 477.5 – 25.3	15 – 537.6 – 7.6 11 – 394.2 – 20.9

[a] Hunting District size - km^2 (USFS ownership within HD - km^2).
[b] Total Hunting District, Number of cover blocks – km^2 – cover blocks as % of HD.
[c] USFS ownership, Number of cover blocks – km^2 – cover blocks as % of USFS ownership.

Elevation

We also compared elevation of kill sites and of live elk during the general hunting season for bulls and antlerless elk (Table 10.4). There were no differences in elevation between bull and antlerless locations during all but one period (*t*-tests, all $P > 0.22$). The exception was that kill locations of bulls during severe weather years of 1991, 1994, and 1996 averaged 87 m higher than locations of antlerless kills during the same years ($t = 2.10$, P = 0.04).

Table 10.4. Mean elevation in meters (sample size) of kill and live locations for bulls and antlerless elk during the general hunting season, 1984-1996, Gravelly-Snowcrest Mountains.

	All Years		1991, 1994, 1996		All Other Years	
	Kill	Live	Kill	Live	Kill	Live
Bull	2365 (156)	2426 (130)	2281 (68)	2358 (31)	2429 (88)	2447 (99)
Antlerless	2329 (266)	2425 (862)	2194 (91)	2340 (130)	2399 (175)	2441 (732)

Although not significant except in 1991, 1994, and 1996, average elevation for bulls was always higher than for antlerless elk. For all years combined, kill locations were lower in elevation for bulls ($t = -2.03$, P = 0.04) and antlerless elk ($t = -5.29$, P <0.001) than locations of living elk. When separated into the smaller sample groups of 1991, 1994, and 1996 vs all other years, antlerless kill elevations remained lower than live locations (P ≤0.05). However, elevations of bull kill and live locations were not different (P >0.11). Lower sample size may explain most of this result, but possibly hunters ranged higher in elevation to harvest bulls. Both kill ($t = -5.65$, P <0.001) and live ($t = -4.35$, P <0.001) locations were lower for antlerless elk during severe weather years of 1991, 1994, and 1996 than during other years. The same comparison for bulls indicated lower elevations for kill sites in 1991, 1994, and 1996 ($t = -3.52$, P <0.001) but a marginally significant relationship for elevation of live bulls ($t = -1.87$, P = 0.06).

When much snow and cold arrived early in the hunting season as in 1991, 1994, and 1996, elk were forced to lower elevations and compressed into a smaller total area nearer roads. Elk kill increased in those years. The fact that kill locations were lower in elevation than locations of live elk was consistent with the earlier finding that kill locations were closer to roads than live locations. Fewer roads are present at higher elevations. That kill locations for bulls were higher in elevation than for antlerless elk, at least during severe weather years, also supported our conclusion that hunters were willing to work harder to harvest bulls than antlerless elk.

Vegetation Type

We described vegetation type classification in Methods and in Appendix Table D1. For forest types, the Gold classification represented mature or overmature trees. Juvenile classification represented pole size trees from 20 feet to full grown. Infant classification represented seedling or saplings < 20 feet tall. We did analysis of interaction of elk locations and vegetation types only within the Forest boundary. Similar vegetation type files were not available for other areas. We intersected the vegetation map with both point locations and a buffer area of 100 m radius around kill sites and telemetry locations of living elk.

Kill locations of antlerless elk by habitat were not distributed differently than availability at the point level of analysis (Table 10.5). Use of the 100 m buffer indicated fewer kill locations ($\chi^2_1 = 3.73$, $P = 0.05$) within/near sagebrush habitat than would be expected based on availability. Locations of living antlerless elk during the general hunting season were distributed less frequently in sagebrush habitat than availability for point ($\chi^2_1 = 92.4$, $P < 0.0001$) and buffered ($\chi^2_1 = 170.59$, $P < 0.0001$) locations. Fewer living antlerless elk were distributed in the sagebrush type than were kill sites of antlerless elk for point locations ($\chi^2_1 = 61.3$, $P < 0.0001$) and buffered locations ($\chi^2_1 = 47.7$, $P < 0.0001$). Point locations of antlerless elk kill sites were proportional to availability for the sagebrush type. The combined data indicated that kill locations for antlerless elk were much more likely to be in or near sagebrush habitat than locations of living elk.

For live antlerless elk, more locations were recorded in the mature Douglas fir (point, $\chi^2_1 = 14.8$, $P < 0.0001$), mature subalpine fir (point, $\chi^2_1 = 92.4$, $P < 0.0001$; buffered, $\chi^2_1 = 23.7$, $P < 0.0001$), mature spruce (point, $\chi^2_1 = 5.9$, $P < 0.015$; buffered, $\chi^2_1 = 19.2$, $P < 0.0001$, and whitebark pine (point, $\chi^2_1 = 21.6$, $P < 0.0001$; buffered, $\chi^2_1 = 23.8$, $P < 0.0001$) types than expected based on availability of types (Table 10.5).

Fewer locations of living antlerless elk than kill locations were in the aspen type (point, $\chi^2_1 = 20.1$, $P < 0.0001$; buffered, $\chi^2_1 = 5.4$, $P < 0.02$). More locations of living antlerless elk than kill locations were in mature Douglas fir (point, $\chi^2_1 = 14.8$, $P < 0.0001$), juvenile lodgepole (point, $\chi^2_1 = 3.78$, $P = 0.05$), mature subalpine fir (point, $\chi^2_1 = 9.6$, $P < 0.002$; buffered, $\chi^2_1 = 17.0$, $P < 0.0001$), mature spruce (buffered, $\chi^2_1 = 5.6$, $P < 0.018$), and whitebark pine (point, $\chi^2_1 = 4.3$, $P = 0.04$; buffered, $\chi^2_1 = 6.4$, $P = 0.01$) types (Table 10.5). During the general hunting season, locations of living antlerless elk were significantly more associated with mature timber stands than were kill locations (points, $\chi^2_1 = 32.4$, $P < 0.0001$).

For bull elk, both kill locations (buffered, $\chi^2_1 = 5.8$, $P < 0.016$) and locations of living bulls (point, $\chi^2_1 = 22.3$, $P < 0.0001$; buffered, $\chi^2_1 = 35.0$, $P < 0.0001$) occurred less in the sagebrush type than expected based on availability (Table 10.6). Both kill sites (point, $\chi^2_1 = 4.2$, $P = 0.04$) and locations of living bull elk (point, $\chi^2_1 = 6.5$, $P < 0.01$; buffered, $\chi^2_1 = 6.3$, $P = 0.01$) were in the whitebark pine type more than expected based on availability.

Living bull elk were in the mature lodgepole pine type in greater proportion than were bull kill sites (points, $\chi^2_1 = 4.7$, $P = 0.03$; buffered, $\chi^2_1 = 4.2$, $P = 0.04$). A much higher proportion of bull kill sites were in the sagebrush type (points, $\chi^2_1 = 14.4$, $P < 0.0002$; buffered, $\chi^2_1 = 12.3$, $P < 0.005$) compared to locations of living bulls. Vegetation type of kill locations and locations of living elk were distributed similarly for bulls and antlerless elk. The only significant difference between bulls and antlerless elk was that a higher proportion of locations of living bull elk were in the mature lodgepole pine type than for living antlerless elk ($\chi^2_1 = 9.8$, $P < 0.002$).

Table 10.5. Locations of hunter-killed and living antlerless elk during the general hunting season (20 Oct. – 1 Dec.) by vegetation type, 1984-1996.

			Antlerless locations – General hunting season			
			Points		Within 100 m	
Veg. Type[a]	Hectares	% of area	Kill	Live	Kill	Live
Aspen	4,913	2.6	12(6.4)[b]	7(1.0)B[c]	19(5.2)	37(2.7)B
DFencr	5,429	2.8	8(4.2)	19(2.7)	18(4.9)	49(3.6)
DFGold	28,264	14.7	22(11.6)	158(22.8)AB	59(16.0)	233(17.2)
DFinf	2,906	1.5	2(1.1)	4(0.6)	4(1.1)	12(0.9)
DFjuv	544	0.3	0	0	4(1.1)	2(0.2)
Dry Mead	7,970	4.2	9(4.8)	23(3.3)	20(5.4)	58(4.3)
LPGold	15,121	7.9	14(7.4)	65(9.4)	32(8.7)	135(10.0)
LPinf	3,397	1.8	2(1.1)	1(0.1)	7(1.9)	10(0.7)
Lpjuv	3,753	2.0	1(0.5)	21(3.0)B	6(1.6)	42(3.1)
PF	1,790	0.9	4(2.1)	6(0.9)	9(2.4)	24(1.8)
Rock	6,615	3.4	6(3.2)	13(1.9)	16(4.3)	62(4.6)
SAFencr	79	Tr	0	2(0.3)	0	3(0.2)
SAFGold	9,866	5.1	8(4.2)	83(12.0)AB	12(3.3)	136(10.0)AB
SAFinfjuv	1,069	0.6	0	6(0.9)	1(0.3)	11(0.8)
Sage	63,374	33.0	67(35.5)	80(11.5)AB	98(26.6)A	163(12.0)AB
SGold	3,169	1.7	3(1.6)	27(3.9)A	7(1.9)	63(4.7)AB
WB	23,484	12.2	28(14.8)	150(21.6)AB	49(13.3)	257(19.0)AB
Wet Mead	7,634	4.0	3(1.6)	29(4.2)	8(2.2)	59(4.4)
Other	2,779	1.5	0	0	0	0
TOTAL	192,157					
No. Points			189	694		
No. Hits					369	1,356

[a] Vegetation types described in Appendix Table C.

[b] Number (%).

[c] A = different than availability at $P \le 0.05$, B = kill and live locations distributed differently by type at $P \le 0.05$.

Unsworth et al. (1998) reported that cow elk and ≥2-year-old bull elk preferred open timber habitats during fall in non-roaded habitat, but preferred more heavily timbered habitat in areas with roads. Hurley (1994) reported that bull elk used mature timbered types more during hunting season than before hunting season and that disproportionate hunter harvest occurred in areas with open roads. Together with our findings, results of these studies indicated that use of mature timber by elk during fall is likely a response to hunting pressure and that open roads and sparse hiding cover increase elk vulnerability to hunting mortality.

Table 10.6. Locations of hunter-killed and living bull elk during the general hunting season (20 Oct. – 1 Dec.) by vegetation type, 1984-1996.

			Bull locations – General hunting season			
			Points		Within 100 m	
Veg. Type[a]	Hectares	% of area	Kill	Live	Kill	Live
Aspen	4,913	2.6	5(5.0)[b]	1(1.0)	9(4.7)	5(2.4)
DFencr	5,429	2.8	3(3.0)	2(2.0)	6(3.1)	7(3.4)
DFGold	28,264	14.7	12(11.9)	18(17.7)	30(15.6)	31(15.1)
DFinf	2,906	1.5	0	3(3.0)	0	4(1.9)
DFjuv	544	0.3	0	0	0	1(0.5)
Dry Mead	7,970	4.2	3(3.0)	1(1.0)	7(3.7)	12(5.8)
LPGold	15,121	7.9	9(8.9)	20(19.6)AB[c]	14(7.3)	28(13.6)B
LPinf	3,397	1.8	0	1(1.0)	2(1.0)	2(1.0)
Lpjuv	3,753	2.0	4(4.0)	3(3.0)	9(4.7)	4(1.9)
PF	1,790	0.9	2(2.0)	2(2.0)	3(1.6)	5(2.4)
Rock	6,615	3.4	2(2.0)	2(2.0)	5(2.6)	6(2.9)
SAFencr	79	Tr	0	0	0	0
SAFGold	9,866	5.1	4(4.0)	9(8.8)	13(6.8)	15(7.3)
SAFinfjuv	1,069	0.6	0	0	0	0
Sage	63,374	33.0	27(26.7)	7(6.9)AB	42(21.9)A	19(9.2)AB
SGold	3,169	1.7	1(1.0)	2(2.0)	7(3.7)	8(3.9)
WB	23,484	12.2	23(22.8)A	26(25.5)A	35(18.2)	44(21.4)A
Wet Mead	7,634	4.0	5(5.0)	5(5.0)	10(5.2)	15(7.3)
Other	2,779	1.5	1(1.0)	0	0	0
TOTAL	192,157					
No. Points			101	102		
No. Hits					192	206

[a] Vegetation types described in Appendix Table C.

[b] Number (%).

[c] A = different than availability at $P \leq 0.05$, B = kill and live locations distributed differently by type at $P \leq 0.05$.

We also analyzed locations of elk relative to vegetation type during the calving period (Table 10.7). The location data (Fig. 10.1) were for radiocollared female elk ≥3 years old. Thus, the data do not represent calf bed locations, but rather areas of use of cows of productive age, and presumably their calves. This represents a macro level description of calving areas. We designated 2 periods; 17 days around the peak of calving (25 May - 10 June) and a broader period of 32 days (20 May – 20 June). Calving area locations were widely dispersed across the study area, including in Idaho and Yellowstone National Park (Fig. 10.1). However, enough clumping of locations occurred that at least 19 calving areas could be delineated for Montana portions of the population range (Fig. 10.1).

The aspen type was represented in a greater proportion of locations of cow elk than its availability during the concentrated calving period (points, $\chi^2_1 = 10.3$, $P = 0.001$; buffered, $\chi^2_1 = 26.4$, $P < 0.0001$) and the broader period (points, $\chi^2_1 = 10.5$, $P = 0.001$; buffered, $\chi^2_1 = 34.7$, $P < 0.0001$). The sagebrush type was also represented with locations in a greater proportion than availability during the concentrated period (point, $\chi^2_1 = 4.2$, P

= 0.04). Sagebrush was used in proportion to its availability during other periods and methods of analyses. Compared to other periods, such as the hunting season, proportional use of the sagebrush type represented increased usage during the calving period.

Mature subalpine fir during both calving periods and methods and whitebark pine during the concentrated calving period were underrepresented in locations compared to availability (all $\chi^2_1 > 4.0$, all $P \leq 0.05$). This appeared to be primarily an elevational relationship. Calving occurred at lower elevations, which also partially accounted for high use of sagebrush and aspen types. Experience with mule deer (Hamlin and Mackie 1989) indicated that early habitat use by newborn ungulates was related to thermoregulation. For the first week or so, newborn mule deer required open habitats subject to warming by sunlight. After that, they used habitats with greater overhead cover. This likely also occurred with elk, and thus the importance of sagebrush habitats, which allow sunlight warming and also some visual cover.

Table 10.7. Locations of radio-transmitter collared cow elk ≥ 3 years old in relation to vegetation type during the calving period, 1984-1997.

			Calving 20 May-20 June		Calving 25 May-10 June	
Veg. Type[a]	Hectares	% of area	Points	100m radius	Points	100m radius
Aspen	4,913	2.6	38(6.6)[b]A[c]	92(8.2)A	28(8.0)A	61(9.2)A
DFencr	5,429	2.8	22(3.8)	53(4.7)A	14(4.0)	28(4.2)
DFGold	28,264	14.7	83(14.3)	166(14.8)	48(13.7)	94(14.2)
DFinf	2,906	1.5	4(0.7)	8(0.7)	2(0.6)	4(0.6)
DFjuv	544	0.3	6(1.0)	10(0.9)	0	4(0.6)
Dry Mead	7,970	4.2	21(3.6)	46(4.1)	8(2.3)	25(3.8)
LPGold	15,121	7.9	53(9.1)	94(8.4)	31(8.9)	64(9.7)
LPinf	3,397	1.8	6(1.0)	13(1.2)	2(0.6)	7(1.1)
Lpjuv	3,753	2.0	9(1.6)	20(1.8)	9(2.6)	14(2.1)
PF	1,790	0.9	13(2.2)	26(2.3)A	2(0.6)	12(1.8)
Rock	6,615	3.4	10(1.7)	41(3.7)	8(2.3)	20(3.0)
SAFencr	79	Tr	0	0	0	0
SAFGold	9,866	5.1	12(2.1)A	32(2.9)A	8(2.3)A	19(2.9)A
SAFinfjuv	1,069	0.6	1(0.2)	5(0.5)	1(0.3)	2(0.3)
Sage	63,374	33.0	207(35.7)	338(30.1)	142(40.6)A	220(33.3)
SGold	3,169	1.7	11(1.9)	26(2.3)	7(2.0)	14(2.1)
WB	23,484	12.2	64(11.0)	114(10.2)	27(7.7)A	49(7.4)A
Wet Mead	7,634	4.0	16(2.8)	39(3.5)	10(2.9)	24(3.6)
Other	2,779	1.5	4(0.7)	0	3(0.9)	0
TOTAL	192,157					
No. Points			580		350	
No. Hits				1123		661

[a] Vegetation types described in Appendix Table C.

[b] Number (%).

[c] A = different than availability at $P \leq 0.05$.

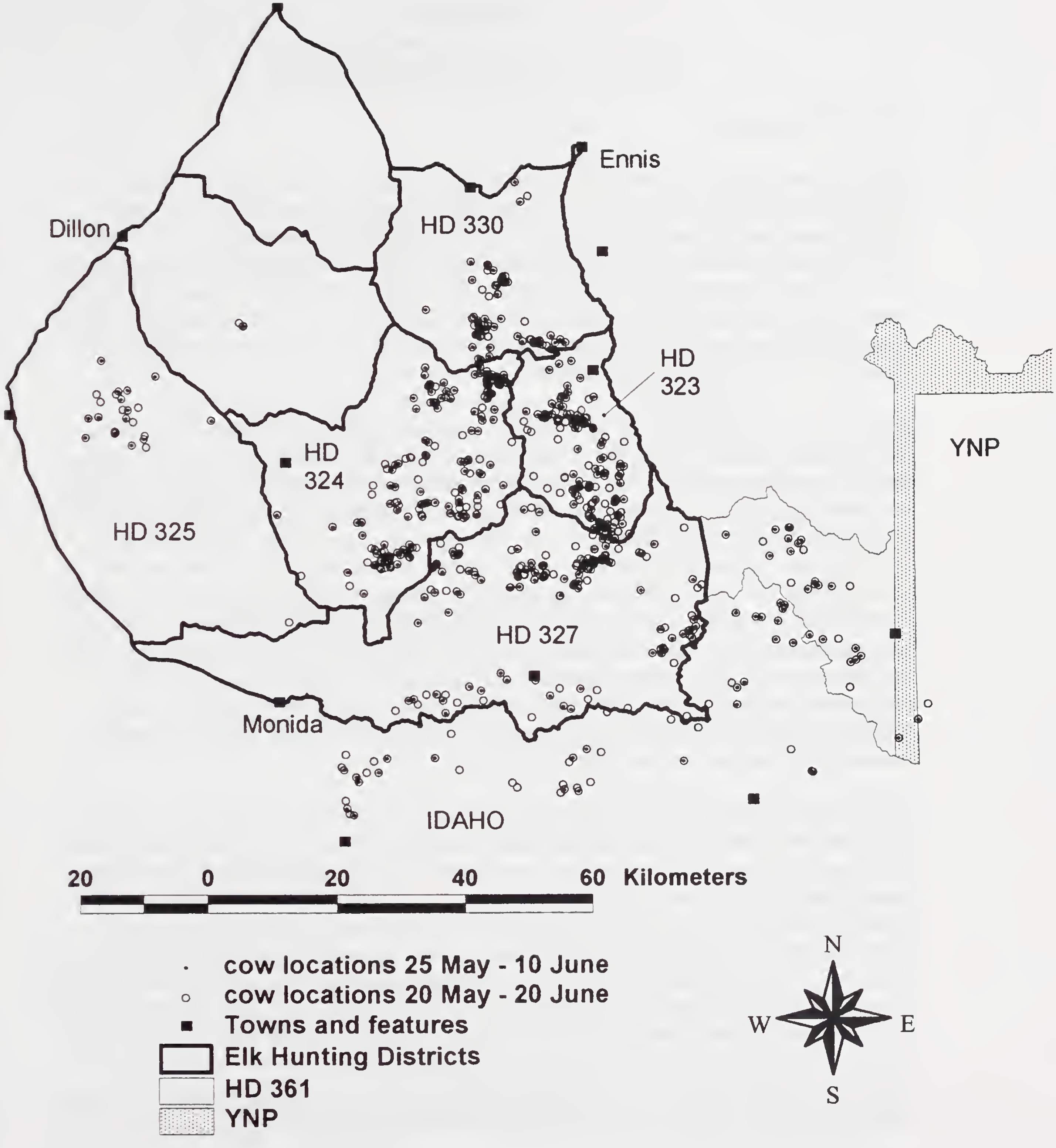


Figure. 10.1. Locations of marked cow elk ≥3-years-old during 2 different calving periods, 25 May – 10 June and 20 May – 20 June, 1984-1997.

CHAPTER 11

EFFECT OF HUNTING REGULATIONS

Bull:100 Cow Ratios

Bull:100 cow (Fig. 11.1) and BTB:100 cow ratios (Fig. 11.2) generally increased throughout the study period. There was no easily discernible upward jump in total bull:100 cow ratios coinciding with implementation of BTB regulations in 1990 (Fig. 11.1). However, the slope of the regression line for years 1991-2000 was positive ($F = 11.2$, $P = 0.01$). Much of the upward bias was for 1998-2000, all years following other years of poor hunting success. Except for 1980 and 1981 (Table 6.3, 6.4, and 6.5), we observed little substantial difference in total bull:100 cow ratios or percent bulls in the population for the entire period back to the late 1960s.

BTB:100 cow ratios (Fig. 11.2) appeared to occur at 3 incremental levels. The levels were an early period (1981-1984) when some of the area remained open to hunting any bull, a mid-period (1985-1990) when most of the area was under BAB regulations, and the period of BTB regulations after 1990. Slopes of regression lines for 1981-1984 and 1985-1990 did not differ from zero ($P = 0.90$ and 0.72, respectively), indicating that BTB:100 cow ratios did not change significantly within either period. However, the positive slope for 1991-2000 was significant ($F = 10.4$, $P = 0.01$), indicating an increase in BTB:100 cow ratios through the period. During this period, points below the overall regression line (Fig. 11.2) were either years following heavy harvests (1992, 1995, 1997) or years when elk were widely dispersed in winter (1993). Points above the overall regression line (1991, 1994, 1998, 1999, 2000) were years following light harvests. Weather during the hunting season appeared to be the major factor affecting hunting success and thus post-season BTB:100 cow ratios.

It is not certain that low bull:100 cow and low calf:100 cow ratios recorded in spring 1980 and 1981 were accurate. Based on age structure of 1984 hunter-killed female elk, the 4-year-old class (1981 cohort) was proportionally the largest recorded during the study (Table 6.8). Similarly, the 5-6-year-old class of the 1985 harvest (1980 and 1981 cohorts) was proportionally the third largest recorded during the study (Table 6.8). Coinciding with this, total numbers of yearling bulls harvested (Figs. 8.9 and 8.10) during 1981 and 1982 (1980 and 1981 cohorts) were at the highest level recorded. Therefore, it is possible that high numbers of yearling bulls were produced, but heavy harvests left few to be recorded in post-season classifications. This would mean that bull:100 cow ratios recorded during 1980 and 1981 were accurate, but calf:100 cow ratios were underestimated. However, we caution that estimating size of a calf cohort based only on its representation in the 4- to 6-year-old age classes may be misleading.

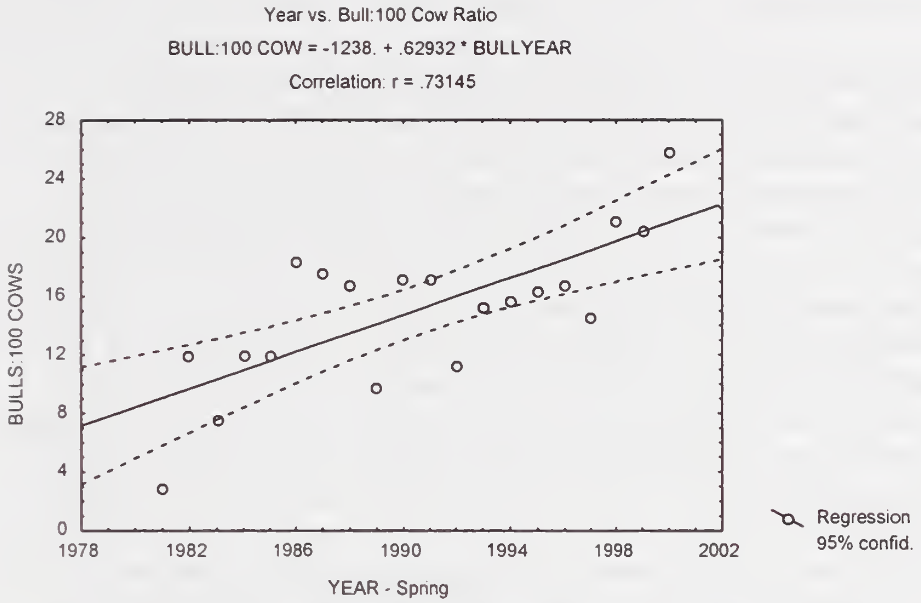


Figure 11.1. Bull:100 cow ratios in spring plotted against year of observations, Gravelly-Snowcrest Mountains, 1981-2000.

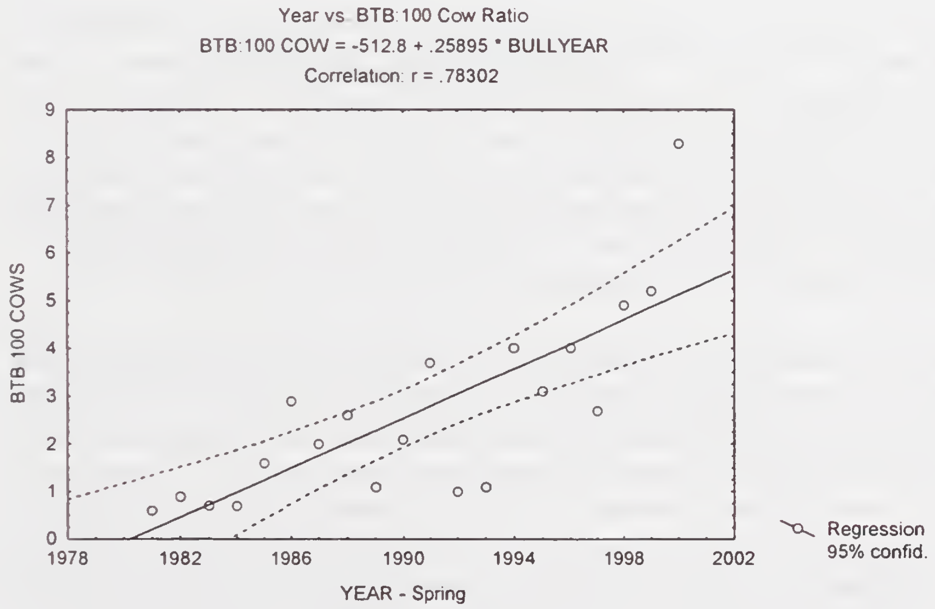


Figure 11.2. BTB:100 cow ratios in spring plotted against year of observation, Gravelly-Snowcrest Mountains, 1981-2000.

Calf Production and Recruitment

Other studies (Hines and Lemos 1979, Prothero et al. 1979) suggested that low proportions of mature bulls in elk populations might negatively affect calf production and/or survival. This information, along with low observed calf:100 cow and low bull:100 cow ratios in the Gravelly-Snowcrest Mountains in 1980 and 1981, led to initiation of this study. We were to follow the effects of a regulation change that was intended to increase the number of 2-year-old breeding bulls in a population comprised primarily of yearling breeding bulls. After these earlier studies, Noyes et al. (1996) conducted a well-designed study on the effects of bull age on elk reproduction at the Starkey Experimental Forest and Range Experiment Station in Oregon. Although pregnancy rates were not significantly related to age of bulls, they found that conception dates were related to bull age. Significantly earlier conception dates occurred for cows bred by bulls ≥3 years of age than for cows bred by bulls ≤2 years of age. Theoretical advantages to earlier and more synchronous breeding are that calves are larger and stronger entering winter and predator swamping may occur at birthing time, all of which increases survival. A concentrated calving period results in most of the population of newborn calves quickly passing through the vulnerable stage rather than young being vulnerable to predators through a longer period.

We found no differences (all $P > 0.32$) in pregnancy rates between 1984-1990 (effect of BAB regulations) and 1991-1995 (BTB regulations) among female age classes 1, 2, and ≥3-year-old elk. All pregnancy rates were near the species maximum. Summer calf:100 cow ratios observed during the period of AB seasons (1968-1979) were near the maximum possible, averaging 62:100, indicating no problem with pregnancy during that period. As stated earlier, we did not have data to test for differences in conception dates. Mean diastema length of hunter-killed calves, a possible surrogate measurement for conception date, did not differ ($P = 0.56$) between 1984-1990 and 1991-1997.

We further tested for a relationship between bull:100 cow and BTB:100 cow ratios and calf:100 cow ratios by combining classifications from the WCWMA and BTWMA. We then plotted bull:100 cow and BTB:100 cow ratios against calf:100 cow ratios 2 years later. That is, the bulls recorded in spring 1981 bred cows in autumn 1981. Those cows produced calves in June 1982 and we made calf:100 cow classifications of this cohort in Feb-Mar 1983. Bulls recorded in spring were all ≥2 years old at breeding. Bulls recorded as BTB in spring were all ≥3 years old at breeding. Data for these plots were available for bull classifications made from spring 1981 through spring 1998. To compute missing data for 1985, we estimated calf:100 cow ratio from subsequent age structure data. We found no significant positive relationship between bull:100 cow (Fig. 11.3) or BTB:100 cow ratio (Fig. 11.4) and calf:100 cow ratio as bull:100 cow ratio varied from 2.9 - 21.2:100 and BTB:100 cow ratio varied from 0.6 - 4.9:100. The relationship between BTB:100 cow ratio and calf:100 cow ratio was negative and marginally significant ($F = 3.64$, $P = 0.07$). Although this did not mean that calf production declined as a consequence of increased numbers of BTB, it did indicate that factors other than number of breeding BTB were most important to calf production/survival during the period.

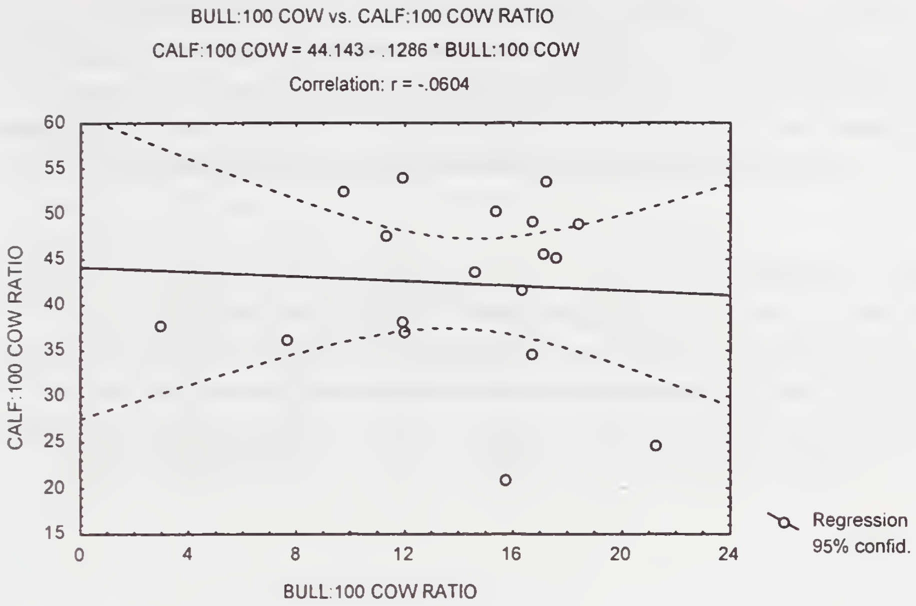


Figure 11.3. Calf:100 cow ratio in late winter-spring plotted against the ≥2-year-old bull:100 cow ratio of the breeding season that produced the calves, Gravelly-Snowcrest Mountains, 1981-2000.

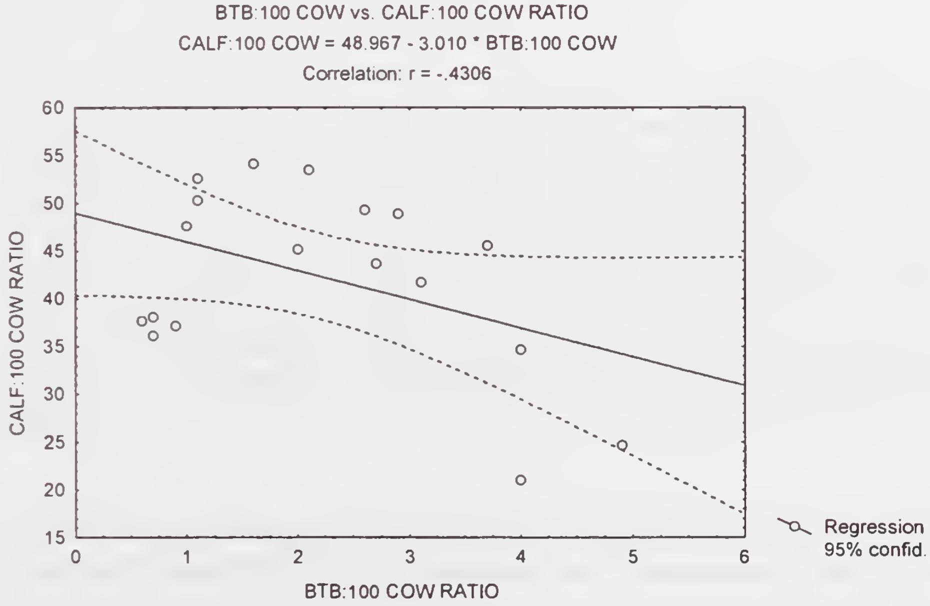


Figure 11.4. Calf:100 cow ratio in late winter-spring plotted against the ≥3-year-old bull:100 cow ratio of the breeding season that produced the calves, Gravelly-Snowcrest Mountains, 1981-2000.

Similar results were observed on the Flying D Ranch in HD 311 (Arnaud 1999, Figs. 11.5 and 11.6). This ranch, where hunting access is privately controlled, had a wide range of bull:100 cow and BTB:100 cow ratios during 1981-1999. Bull:100 cow ratios ranged from 8.4 - 76.9:100 cows and BTB:100 cow ratios from 1.9 - 55.7:100 cows. The highest recorded calf:100 cow ratios occurred following seasons with the lowest recorded levels of breeding bulls.

Because of a relative observation bias against bulls, actual bull:100 cow and BTB:100 cow ratios were probably at least slightly higher than the figures we recorded. Considering this, we did not observe short-term negative effects on calf production and survival associated with observed breeding bull ratios in spring as low as 3 bulls:100 cows and 0.6 BTB:100 cows. With average calf survival, these figures are equivalent to 22 bulls (including yearlings):100 cows and 3 BTB:100 cows during the subsequent breeding season.

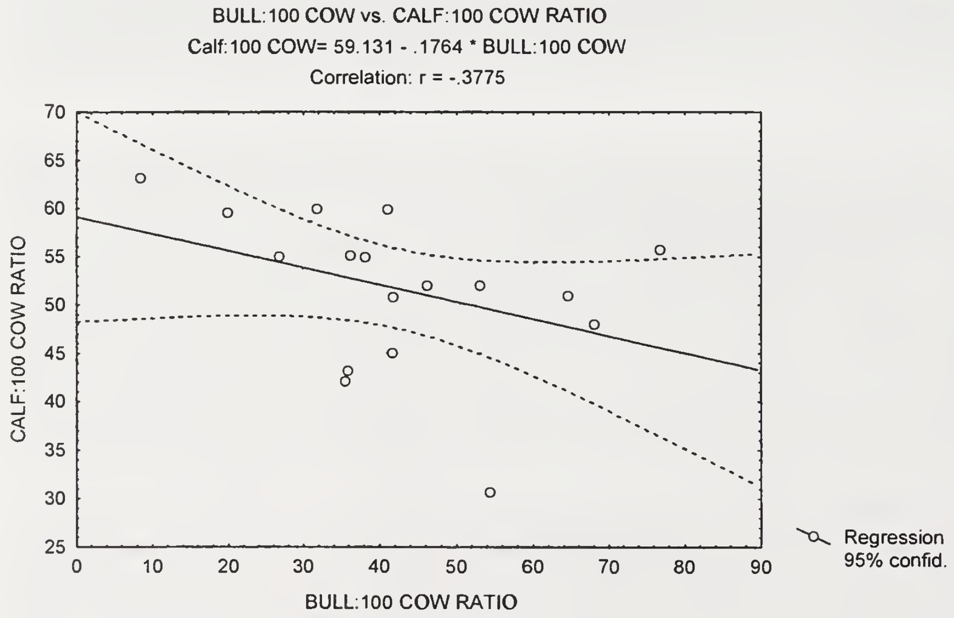


Figure 11.5. Calf:100 cow ratio in late winter-spring plotted against the ≥2-year-old bull:100 cow ratio of the breeding season that produced the calves, Flying D Ranch, 1981-1999.

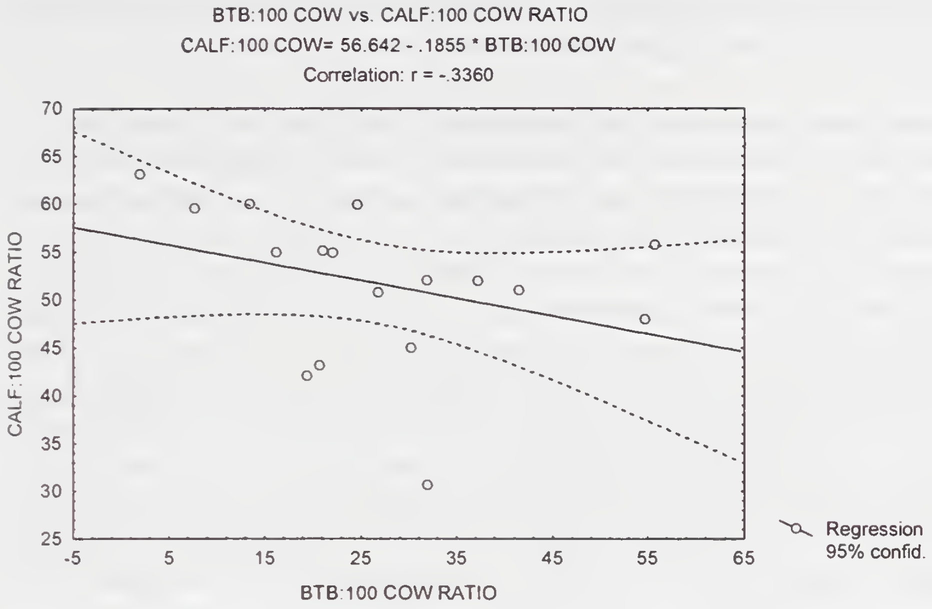


Figure 11.6. Calf:100 cow ratio in late winter-spring plotted against the ≥3-year-old bull:100 cow ratio of the breeding season that produced the calves, Flying D Ranch, 1981-1999.

Overall, production and survival of elk calves in the Gravelly-Snowcrest Mountains was as high or higher than for other elk populations in Montana and the west. This occurred with spring bull:100 cow ratios averaging 14.1:100 cows (range, 2.9 - 21.2) and BTB:100 cow ratios averaging 2.2:100 cows (range, 0.6 - 4.9). During the mid 1980s through the mid 1990s, when calf:100 cow ratios averaged 49.7:100, bull:100 cow ratios averaged 13.0:100 and BTB:100 cow ratios averaged 1.6:100. During recent years (1994-1998) when calf:100 cow ratios declined and averaged 33.2:100, the bull:100 cow and BTB:100 cow ratios during the spring prior to breeding averaged 16.9:100 and 3.7:100, respectively.

Data from Noyes et al. (1996) indicated that when bred by bulls 3 years old or older, 3 of 16 yearling cows (18.8%) were pregnant and 89 of 97 cows ≥2 years old (91.8%) were pregnant. For the Gravelly-Snowcrest population, 32 of 83 of yearling cows (38.6%) were pregnant and 255 of 266 cows 2 years old and older (95.9%) were pregnant. The average age structure of breeding bulls in the Gravelly-Snowcrest Mountains for the last 13 years has been approximately: 60% 1 year old, 30% 2 years old, and 10% ≥3 years old. Expressed another way, this was an average of 4.65 bulls:100 cows that were 3 years old or older during the rut. This somewhat higher estimated ratio based on age structure may account for bulls missed disproportionately on post-season surveys. In either case, this young age structure produced pregnancy rates as high or higher than produced by the 3- to 5-year-old bulls at the Starkey Experiment Station.

Perhaps the reason we see these results can be explained more clearly by "doing the arithmetic." For the Gravelly-Snowcrest Mountains, we estimate (in round numbers) about 12,000 elk in the preseason (breeding) population in recent years. On average, this total was comprised of 2,500 bulls (1,500 yearlings, 750 2 year olds, and 250 ≥3 year olds), 6500 cows, and 3,000 calves. Because only about 40% of yearling cows breed and about 4% of older cows do not breed, there were about 5,400 breeding cows. If each of the 250 bulls ≥3 years old breeds 20 cows (reasonable, J. Moseley, pers. comm.), 5,000 cows, or 93% of the total are bred. Mostly 2-year-olds might breed the remainder. Even if each bull ≥ 3 years old breeds only 10 cows, almost half of breeding cows would be bred by bulls ≥ 3 years old. Thus, although 10% of bulls ≥3 years old (4.65:100 cows) seems low, that percentage can make a large impact on total breeding. This indicated that even with an "age-of-bull effect" on conception dates, it's potential influence would be minor and/or hard to detect "in the wild" with the multiple factors influencing conception dates and calf survival.

Because this study did not begin until 1984, we can not definitively answer the question that began the study: Why was calf production/survival low during 1979-1980 and 1980-1981? We can only speculate that rather than low calf production/survival being the result of low numbers of breeding bulls, the severe winter of 1979-1980 (most severe in 30 years, Figs. 2.5, 2.6) contributed to low calf production/survival.

Age of Bulls

At the end of the period of any antlered bull regulations in the Gravelly-Snowcrest Mountains, yearling bulls averaged about 75% of the bull harvest (Fig. 9.10). At the end of the period of branch-antlered bull regulations, yearling bulls averaged about 25% of the bull harvest (Fig. 9.10). This change occurred as a result of the regulation definition; about 65 - 80 % of yearlings were spikes, protected by regulation. With the change to brow-tined bull regulations, yearling bulls averaged about 4% of the bull harvest (Fig. 9.10). These yearling bulls included a very few that had brow-tined antlers; most were self-reports of illegal harvest. The proportion of yearlings in the harvest changed by definition of the regulations, thus average age of the harvest increased by definition. To equally compare ages among all 3 periods, we could include only bulls ≥2 years old. We examined whether average age of harvested bulls ≥2 years old changed.

For the Gravelly-Snowcrest Mountains, average age of harvested bulls ≥2 years old was the same (2.30 years, Table 11.1) for the period of BTB regulations (1991-1996) as for BAB regulations (1984-1990). Distribution of ages also was not different between the periods ($\chi^2_4 = 2.47$, $P = 0.65$). For this population with its low security habitat conditions and hunting pressure, legal bulls were harvested at about the same annual rate (75 %) regardless of regulation. Only bulls protected by regulation (yearlings) had a lower mortality rate. A probable increase in numbers of older bulls occurred after 1996, but this appeared related to weather conditions unfavorable to harvest rather than regulation type.

However, it is possible that a small increase in escapement by bulls ≥ 3 years old occurred. This increase, if it occurred, is small enough that many years may be required to record an increase in average age or BTB:100 cow ratio. Also, we note that although hunter numbers have increased, the average age of harvested bulls has not declined. Average age and/or BTB:100 cow ratios may have increased had numbers of hunters not also increased.

Table 11.1. Mean age of harvested bull elk (≥ 2 years old) compared among areas and hunting season types.

Area		Mean age			
Gravelly-Snowcrest	Regulation[a]	BAB	BTB		
	Years	1984-1990	1991-1996		
	Mean Age	2.30(572)[b]	2.30(797)		
Bitterroot HD 250	Regulation	AB	BTB		
	Years	1982-1991	1992-1996		
	Mean Age	3.12(418)	3.02(423)		
Bitterroot HD 270	Regulation	AB	BTB		
	Years	1982-1991	1992-1996		
	Mean Age	2.96(665)	2.94(924)		
Gallatin-Madison HDs 301,310,311, 360,361,362[c]	Regulation	AB	BAB	BTB	
	Years	1980-1985	1987-1989	1991-1996	
	Mean Age	4.02(804)	3.04(649)	3.59(1115)	
HDs 319 and 341	Regulation	AB	AB	BAB	BTB
	Years	1979-1982	1983-1986	1987-1990	1991-1995
	Mean Age	2.42(94)	2.36(138)	2.46(262)	2.45(295)
Pioneers HDs 331 and 332	Regulation	AB	AB	AB	AB
	Years	1979-1982	1983-1986	1987-1990	1991-1995
	Mean Age	2.76(50)	2.72(64)	2.71(129)	2.66(61)

[a] Regulation – AB = Antlered Bull, BAB = Branch-antlered Bull, BTB = Brow-tined Bull.

[b] Mean Age (sample size).

[c] Bulls from the lightly hunted Flying D Ranch in HD 311 excluded.

Effects of regulation might vary with habitat and hunting pressure so we examined data from other areas to compare with results from the Gravelly-Snowcrest Mountains. Average age of harvested bulls ≥ 2 years old did not change significantly with regulation change in any area except the Gallatin-Madison area, where average age was different (all $P < 0.0001$) among all regulation periods (Table 11.1). Bulls from the lightly hunted Flying D ranch in HD 311 were not included in the samples. For the Gallatin-Madison area (HDs 301, 310, 311, 360, 361, 362) bull age decreased in the following order of season type; AB, BTB, BAB. Both restrictive season types resulted in a younger age structure for harvested bulls (older than yearling) than the antlered bull season. Distribution of individual ages also was different among the season types in the Gallatin-Madison area (all $\chi^2 > 107.8$, all $P < 0.0001$). For both BAB and BTB seasons, the proportion of 2-year-olds increased and older ages decreased compared to the period of AB seasons. Average age of the Gallatin-Madison bull harvest can be affected by weather severity during hunting season. With early severe weather, more elk moving from Yellowstone National Park (older age structure) were available to hunters. Thus we used the longest periods possible for comparisons to smooth out individual year effects. Thus, both BAB and BTB periods had one or more years with ages influenced by YNP elk (e.g.,1988, 1991, Fig. 11.7). Average age of bulls was less during BAB and BTB periods than for the period of AB regulations despite a greater than usual representation of YNP elk in their averages. It appeared that the decline in average age of harvested bulls in the Gallatin-Madison areas under BAB and BTB seasons compared to AB seasons was real.

For the Bitterroot HDs (HD 250 and 270), the overall plot by year (Fig. 11.8) indicated a non-significant ($P = 0.08$) downward trend in age. However, separate plots of the 2 different periods of regulations resulted in a different interpretation. There was a downward trend ($P = 0.01$) in bull age with year under AB regulations (Fig. 11.9) and an upward trend ($P = 0.004$) of age with year under BTB regulations (Fig. 11.10). We tentatively conclude that implementation of BTB regulations in HD 250 reversed a downward trend in average age of bulls ≥2 years old that occurred under AB regulations and initiated an upward trend in average age. Age of harvested bulls has not recovered to pre-1988 levels, however. Further years of data may be necessary to separate the relative effects of recent mild weather and poor hunting success from regulation effect.

Although average age of bulls harvested in HDs 319 and 341 did not change with regulation type (Table 11.1), distribution of individual ages was different among regulation types. More 3-year-old bulls and fewer 2-year-old bulls were harvested with BAB ($\chi^2_2 = 10.01$, $P = 0.006$) and BTB ($\chi^2{}_2 = 9.84$, $P = 0.007$) seasons than AB seasons. Slightly fewer bulls ≥4 years old were recorded under the latter two season types but this difference did not add significantly to the total Chi-square value. Age class distribution was not different ($\chi^2{}_2 = 0.02$, $P = 0.99$) between BAB and BTB seasons. Sample sizes were relatively small for this area, but it appeared that the results were similar to those for the Gravelly-Snowcrest area.

The Pioneer Mountains (HDs 331 and 332) provide somewhat more secure habitat than the Gravelly-Snowcrest Mountains and regulations remained AB throughout the period of study. Although average age of bulls ≥2 years old declined slightly through the period, the decline was not significant ($P = 0.56$). Distribution of individual age classes was also not different among time periods ($\chi^2{}_3$, all $P > 0.11$) for this area. Continued monitoring of the age of harvested bulls will be necessary here, but to this time, age has remained stable with continued AB regulations.

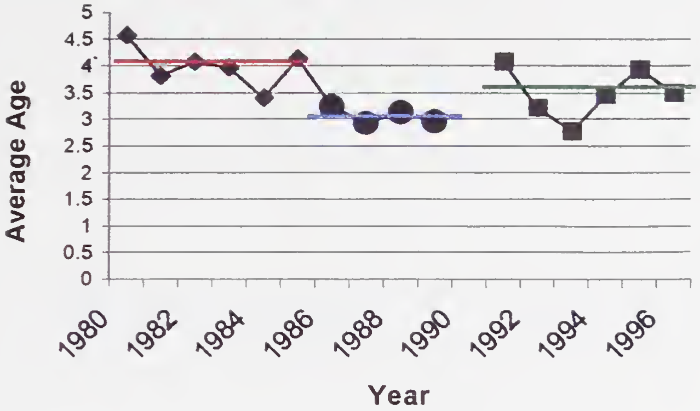


Figure 11.7. Average age of harvested bull elk ≥2 years old in Gallatin-Madison HDs (301, 310, 311, 360, 361, 362), 1980-1996. Diamonds and red mean line = AB seasons, Circles and blue mean line = BAB seasons, and Squares and green mean line = BTB seasons.

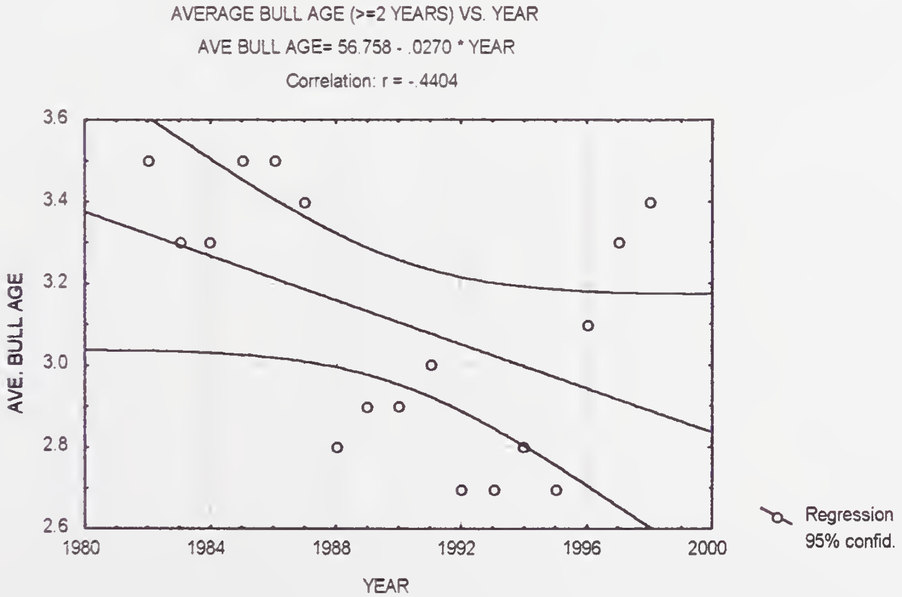


Figure 11.8. Average age of bull elk (≥2 years old) harvested in HD 250 plotted against year of harvest. Antlered bull regulation, 1982-1990 and BTB regulations 1991-1996. First year effect of BTB regulation measured is 1992.

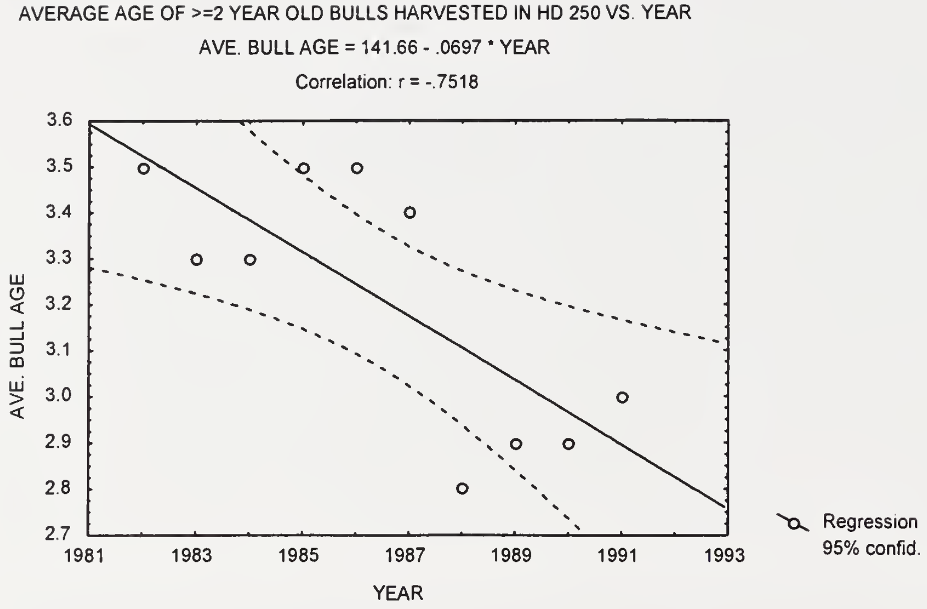


Figure 11.9. Average age of bull elk (≥2 years old) harvested in HD 250 plotted against year of harvest, 1982-1991 (effect of antlered bull regulations).

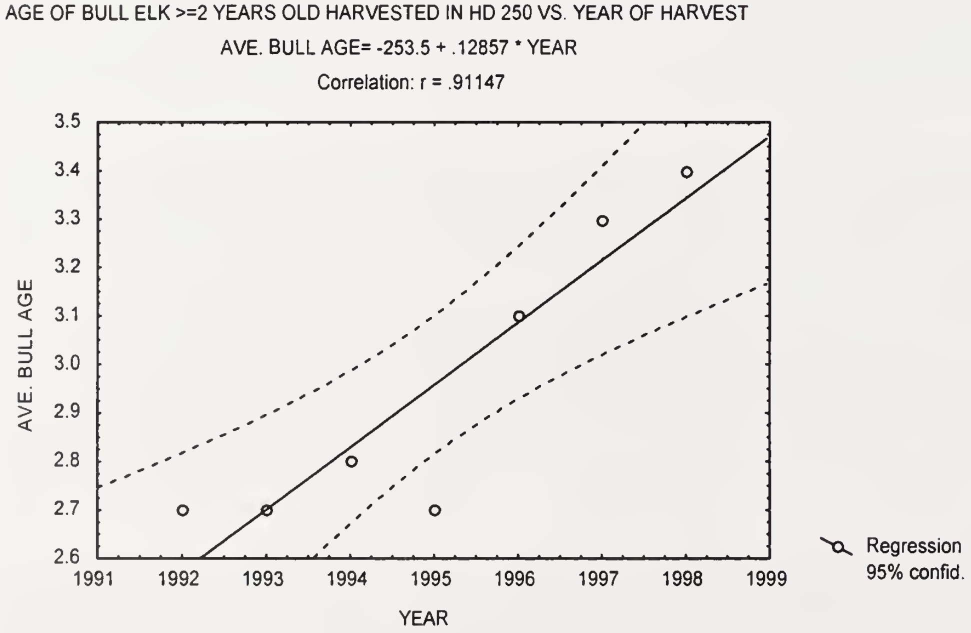


Figure 11.10. Average age of bull elk (≥2 years old) harvested in HD 250 plotted against year of harvest, 1992-1998 (effect of BTB regulation).

Check station data were not available throughout the state to compare bull ages among variable regulations and habitat conditions. Therefore, we used antler characteristics reported in the Statewide Hunter Harvest Questionnaire as a surrogate for age data. We used the hunter-reported percent of bulls with ≥6 x 6 antler points (of those reported with ≥3 x 3 antler points) as an index of occurrence of older bulls. Although not a direct measure, this index will generally follow changes in the proportion of bulls ≥3 years old. For comparisons, we combined hunting units into groups with similar regulation histories and similar habitat/hunter characteristics.

The percentage increase in hunter-reported bulls with antlers ≥6 x 6 point was greatest for Gravelly-Snowcrest HDs during the period of comparison (Table 11.2). However, the Gravelly-Snowcrest area remained the area with the fewest larger-antlered/older bulls harvested. Except for Missouri River Breaks units, the Gravelly-Snowcrest area had the greatest increase in general license hunters during 1985-1995 (slope of regression line = 0.088, $P < 0.00001$). Most of the increase in the Missouri River Breaks (slope = 0.165, $P < 0.00001$) was due to archery hunters.

Most areas where regulations remained AB showed slightly smaller, but similar increases in percent ≥6 x 6 antlered bulls as the Gravelly-Snowcrest Mountains (Table 11.2). Those areas included: HD 100 (Purcell); HDs 101,102,120, and 122 (Salish); HDs 140,141,150, and 151 (Bob Marshall); and HDs 413, 416, 418, 432, 448, 454, and 540 (Little Belts). We observed similar results for limited entry areas: HDs 410, 417, 426, 621, 622, 623, 631, 632, and 700 (Missouri River Breaks); and HDs 411, 412, and 447 (Snowies, Judith and Highwood Mountains). The Purcell, Salish, Little Belts and Missouri River Breaks all showed significant increases in general license hunters during the period (all P < 0.003). Hunter numbers in the Snowy-Judith-Highwood Mountains did not change significantly and hunter numbers decreased ($P = 0.03$) in the Bob Marshall area.

A substantial decrease in larger/older bulls occurred in HD 240 (West Bitterroot) after regulations changed from AB to BTB (Table 11.2) despite no significant change in general license hunter numbers during the period. Small declines or little change in larger/older bulls were observed for the Garnets (HDs 283, 291, and 292), Pioneers (HDs 329, 331, 332), East and Upper Bitterroot (HDS 204, 250, 261, and 270), Lower Clark Fork (HDs 121, 123, 200, and 202), and Rock Creek-Sapphire area (HDs 210, 211, 213, 214, and 216). General license hunter numbers did not change significantly in the Garnets and East-Upper Bitterroot areas, but did increase significantly in the other 3 areas (all $P < 0.05$)

The BTB regulation appeared to have the greatest effect in increasing the size/age of hunter reported bulls for the Gravelly-Snowcrest Mountains despite a substantial increase in hunter numbers during the period. However, many areas that remained open to AB hunting showed nearly similar increases in reported harvest of larger/older bulls over the period despite also having substantial increases in hunter numbers. Thus, general conditions prevailing over a large area (such as lighter harvest due to weather) probably influenced reported bull size/age as much or more than regulation type.

Table 11.2. Percent of harvested bull elk (of those with ≥ 3 x 3 antler points) with ≥ 6 x 6 antler points as reported by hunters on the Statewide Harvest Questionnaire, 1985-1995.

Year	Hunting Districts[a]												
	323 324 326 330	100	101 102 120 122	121 123 200 202	329 331 332	140 141 150 151	210 211 213 214 216	**204 250 261 270**	**240**	283 291 292	413,416, 418,432, 448,454, 540	*410,417, 426,621, 622,623, 631,632, 700*	*411 412 447*
1985	**7.5**	30.8	33.3	28.2	5.6	35.5	35.3	**25.4**	**25.0**	16.8	10.3	*39.0*	*48.2*
1986	**6.2**	32.7	25.9	27.1	21.0	34.4	9.1	**19.8**	**25.9**	20.0	18.6	*47.9*	*50.0*
1987	**9.1**	34.8	36.7	20.2	17.8	34.8	15.9	**27.1**	**33.3**	15.3	4.4	*63.7*	*48.3*
1988	**6.6**	21.2	18.8	24.9	15.9	21.2	19.7	**15.0**	**18.9**	20.5	17.5	*46.5*	*46.7*
1989	**8.4**	20.5	23.2	16.5	16.4	24.5	17.0	**19.9**	**21.5**	14.4	15.2	*51.5*	*41.7*
1990	**6.4**	29.4	15.5	21.5	17.8	11.4	14.0	**15.7**	**31.8**	20.3	14.4	*55.6*	*67.7*
1991	**12.2**	26.9	27.6	22.1	10.8	20.3	20.3	**22.8**	**11.5**	14.5	19.0	*59.5*	*55.7*
1992	**9.9**	33.3	32.9	27.3	12.4	36.9	19.2	**17.3**	**12.5**	13.8	17.4	*56.5*	*59.2*
1993	**5.9**	33.3	42.9	16.0	19.8	36.5	21.7	**26.4**	**10.2**	15.9	16.8	*64.7*	*67.7*
1994	**15.4**	44.2	35.5	31.6	20.8	40.4	24.2	**19.8**	**12.6**	14.4	19.0	*73.9*	*67.3*
1995	**11.1**	32.7	27.3	27.4	13.0	45.3	17.3	**19.9**	**25.9**	20.4	14.9	*65.5*	*61.3*
Pre-BTB[a]	**7.4**	28.2	25.6	23.1	15.8	27.0	18.5	**20.8**	**24.0**	17.9	13.4	*50.7*	*50.4*
Post-BTB[a]	**10.9**	34.1	33.2	24.9	15.4	35.9	20.5	**21.0**	**15.3**	15.8	17.4	*64.0*	*62.2*
Regres. Slope Hunter Nos.[b]	**0.09**	0.04	0.06	0.03	0.08	(-) 0.02	0.04	**(-) 0.01 NS[c]**	**0.01 NS**	0.00 NS	0.05	*0.16*	*0.02 NS*

[a] For Gravelly-Snowcrest hunting districts (**bold**) 1985-90 = ≥ 2-year-old bulls produced under the BAB regulation and 1991-1995 = ≥ 2-year-old bulls produced under the BTB regulation. For Bitterroot HDs (**bold**) 204, 250, 261, 270, and 240, 1992-1995 = ≥2-year-old bulls produced under the BTB regulation. For all other areas that remained AB or limited entry (*italics*), pre- and post-BTB are the years summarized for the Gravelly-Snowcrest HDs for comparison.

[b] Slope of regression line of general license hunter numbers against year. (-) = negative slope.

[c] NS = not significantly different from zero slope (no change). All others significantly different from zero slope.

Four of the areas should be carefully monitored in coming years. Older bulls are relatively few in the Pioneers (HDs 329, 331, 332, Tables 11.1 and 11.2) and hunter numbers there are increasing there at an only slightly slower rate than in the Gravelly-Snowcrest Mountains. Reported numbers of older/larger bulls harvested were stable there despite increases in most other areas during the period. A similar situation exists for the East-Upper Bitterroot but has occurred there despite relatively stable hunter numbers. For the West Bitterroot (HD 240) and Garnet Mountains (HDs 283, 291, 292), declines in hunter-reported harvest of larger/older bulls occurred (Table 11.2) despite a stable trend in general hunter numbers. Another cautionary note must be made here, however. In contrast to hunter-reported antler data, age data from check stations reported earlier (1-3 more years of data) did not indicate an increase in age of harvested bulls for the Gravelly-Snowcrest Mountains and did indicate an increasing trend in bull age during 1996-1998 for the East-Upper Bitterroot area. Because of the conflicting results, it is likely that any change that occurred in either area was small.

Montana has employed the spikes legal/BTB limited entry regulation in the Elkhorn Mountains (HD 380) to provide for older bulls in the breeding population. During a 5-week season anyone with an elk license may shoot a spike bull. Only hunters who apply for and receive a special permit in a drawing may shoot BAB/BTB. This regulation was implemented in 1987 and 50-100 permits for BAB/BTB have been issued annually. Under AB regulations during 1982-1985, total annual bull mortality averaged 90% (DeSimone and Vore 1992). Under the spikes legal/BTB limited entry season, annual mortality averaged 62.5% for yearling bulls and 29.3% for BTB during 1987-1991 (DeSimone and Vore 1992). Annual hunting mortality rates, especially for yearling bulls, may have increased since 1991. Although the total elk population has increased since 1991 there has not been a sustained increase in the number of permits issued for and harvest of BTBs. Presumably, this has occurred because an increase in the mortality rate of yearling bulls has resulted in few recruits into the older bull category. Also, results of the SWHQ indicated that some illegal mortality of BTB occurred.

Despite an apparent lack of increase in the number of bulls ≥2 years old in the population, the average age has increased among those that were recruited to the BTB category. Average age of BTB harvested increased from 3.11 years in 1988-1990, to 5.11 years in 1992-1996, and to 6.17 years in 1999-2000 (DeSimone and Vore 1992, T. Carlsen, pers. comm.). This compares to an average age of 2.31 years for BTB harvested in the Gravelly-Snowcrest HDs during 1992-1996. When yearlings are included in comparing age structure of the harvest, average age was 1.67 years in the Elkhorn Mountains and 2.29 years in the Gravelly-Snowcrest Mountains.

We compared age structure of the total bull harvest in the two areas during 1992-1996 assuming an equal population size and harvest (Fig. 11.11, assumes 1,000 bulls harvested in both areas). For the Elkhorns, 83.6% of the annual harvest would be spikes and for the Gravelly-Snowcrest Mountains, 75.6% of the harvest would be 2-year-old bulls (Fig. 10.11). Harvest of bulls in the Elkhorn and Gravelly-Snowcrest Mountains, respectively, would be 8.8% and 1.8% ≥5 years old, 12.3% and 7.8% ≥4 years old, and 14.3% and 23.2% ≥3 years old. Thus, with an equal harvest of 1,000 bulls on both areas, 824 more spikes and 70 more bulls ≥5 years old would be harvested in the Elkhorn than Gravelly-Snowcrest Mountains. Eight hundred ninety four more 2-, 3-, and 4-year-old bulls would be harvested in the Gravelly-Snowcrest than Elkhorn Mountains.

Results of the branch-antlered and brow-tined bull regulations in the Gravelly-Snowcrest Mountains were similar to results of similar regulation types reported elsewhere (Freddy 1987, Bender and Miller 1999, Biederbeck et al. 2001). Antler point restrictions that protect yearling bulls resulted in only small increases in post-season bull:cow ratios and average age of harvested bulls. Numbers and proportions of bulls ≥4 years old were not increased. Habitat conditions and amount of hiding cover were factors that influenced the effect of brow-tined bull (or ≥3-point) regulations. Annual survival of adult bulls (≥2 years old) was 0.25 in the Gravelly-Snowcrest Mountains, of which about 25% met mimimal hiding cover requirements (Hillis et al. 1991). Annual survival of adult bulls was 0.60 in the Gallatin-Madison HDs, 0.57 in the north coast range of Oregon (Biederbeck et al. 2001), and 0.46 in southwestern Washington (Bender and Miller 1999),

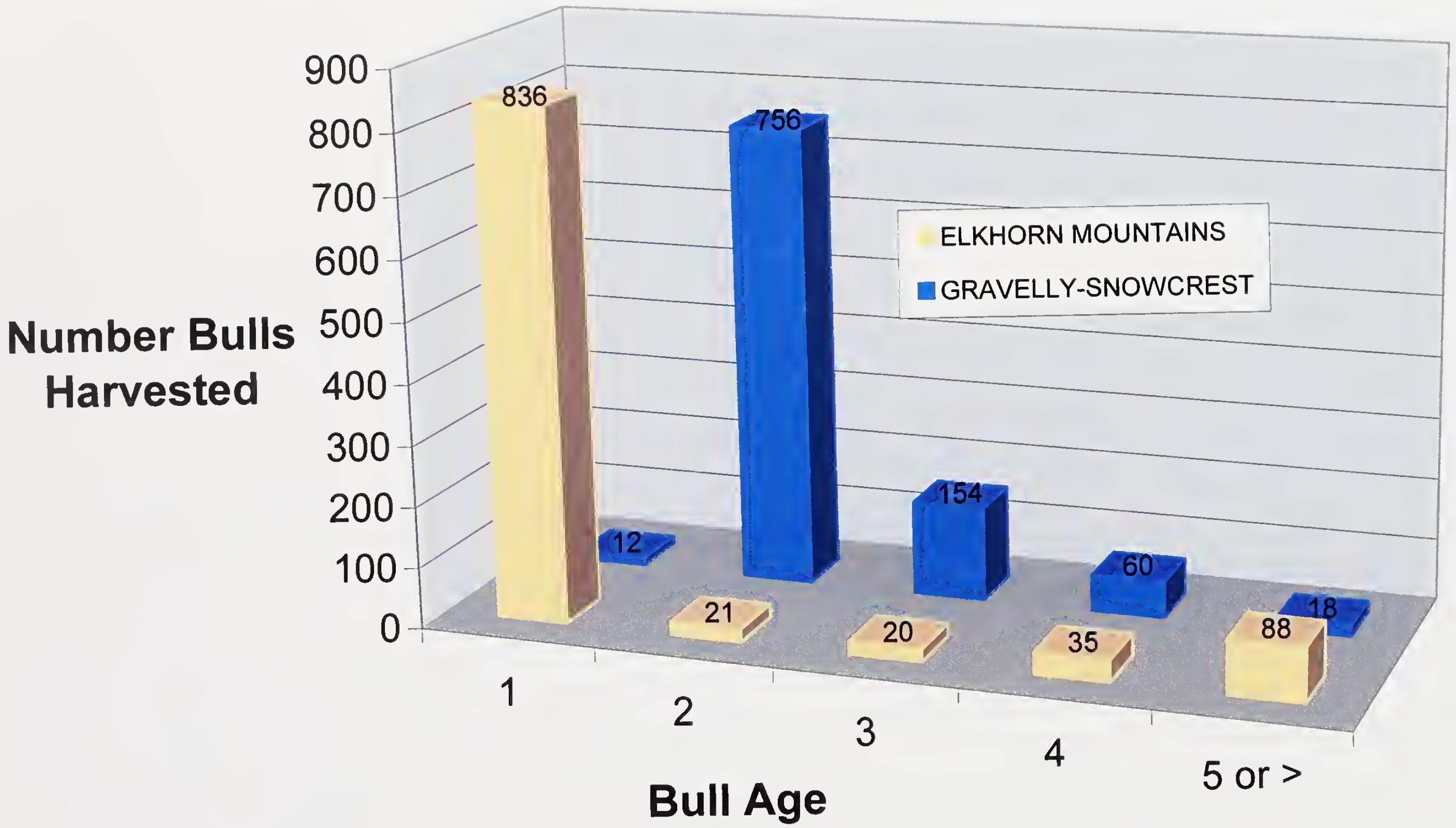


Figure 11.11. Estimated age structure of bull elk harvest in the Gravelly-Snowcrest (HDs 323, 324, 325, 326, 327, and 330) and Elkhorn Mountains (HD 380) assuming equal numbers harvested (1,000), 1992-1996.

all of which were more heavily timbered areas than the Gravelly-Snowcrest Mountains. Only limited entry hunting that substantially reduced hunter numbers resulted in significant increases in post-season bull:cow ratios and increased proportions of bulls ≥4 years old (Freddy 1987, Bender and Miller 1999).

Antler Characteristics

Prior to and following implementation of branch-antlered bull regulations, some biologists and hunters questioned whether the regulation might select against "superior" branch-antlered yearling bulls, reducing their future contributions to the gene pool. This would occur because "spikes" were protected by the regulation while branch-antlered yearlings were legal to harvest. Thus surviving yearlings were disproportionately comprised of "spike-antlered" yearlings (Table 6.6), which would disproportionately contribute to the subsequent gene pool of breeding bulls. Based on prior literature, some believed that larger initial antler size might be carried throughout life and that branching of yearling antlers might reflect "genetic superiority." Limited data for individual bull elk (including their size as calves) in the Elkhorn Mountains suggested that this might be the case (DeSimone and Vore 1992).

Strong positive relationships were found between chest girth and weight for elk (Millspaugh and Brundige 1996) and mule deer fawns (Unsworth et al. 1999). Therefore, we used our limited data on chest girth of 9- to 10-month-old bull calves as an index to initial size and condition. Our samples compared chest girth as calves to mean antler length and mean antler points for 10 and 14 yearling bulls, 24 and 32 2-year-old bulls, and 9 and 13 3-year-old bulls, respectively. There were no significant relationships between chest girth as 9- to 10-month-old calves and subsequent antler points or lengths (all $P > 0.085$). In no cases were the largest antlers associated with the largest chest girth or the smallest antlers associated with the smallest chest girth. We also compared Boone and Crockett antler measurements for 6, 2-year-old and 3, 3-year-old males with chest girth measurements as calves. Again, there was no relationship between chest girth as 9-to10-month-old calves and subsequent Boone and Crockett score for this small sample. All this, together with the information for cohort diastema length for females (Table 4.4), did not indicate a positive relationship between initial and subsequent size/condition.

We had data at the population level to compare antler size between bulls produced under BAB and those produced under BTB regulations. More branch-antlered yearlings survived under BTB regulations (Table 6.6) to both breed and be harvested at older ages. Thus, we believed that if a substantial relationship existed for branch-antlered yearling bulls producing larger antlered older bulls, mean antler size by age should be larger for bulls harvested under BTB regulations. We did not find that bulls produced under BTB regulations had larger antlers than bulls produced under BAB regulations (Table 11.3). Three-year-old bulls produced under BTB regulations had significantly longer antlers than those produced under BAB regulations, but 5 year olds had shorter antlers and 4 year olds had fewer points/side under BTB regulations than BAB regulations. Sample size was small for 4- and 5-year-old bulls, however greater carryover of branch-antlered yearling bulls did not produce a consistent measurable increase in antler size of 2- to 5-year-old bulls in the short-term.

We caution that measurements at the population level are relatively insensitive and would likely only show effects of a strong relationship. Effects, if they occurred, might be small and/or occur after long periods of selection. Lukefahr and Jacobson (1998) found that the amount of heritability for spike versus forked antlers in yearling male white-tailed deer was low. They stated that maternal effects were most important in expression of antler traits of yearling males. For example, birthdate (mothers nutrition) profoundly influenced antler development of yearlings, but this effect was not detectable at 3 years of age (Jacobson 1995a, 1995b). Antler characteristics of ≥ 2-year-old males had moderate to high heritability (Lukefahr and Jacobson 1998). This implied that to genetically select for antler size, yearlings could be harvested without selection, but that some protection of larger antlered older males (trophies) might be effective in increasing antler size.

Table 11.3. Antler length and number of points/antler by age class for known or incisor aged bull elk produced under BAB regulations compared to those produced under BTB regulations, Gravelly-Snowcrest Mountains, 1984-1997.

Season Type[a]	Mean Antler Length(mm)				Mean Antler Points/Side			
	2 Years Old	3 Years Old[b]	4 Years Old	5 Years Old[b]	2 Years Old	3 Years Old	4 Years Old[b]	5 Years Old
BAB	755.4 (576)[c]	857.5 (66)	1004.2 (19)	1127.0 (5)	4.56 (591)	5.27 (71)	5.95 (19)	5.75 (12)
BTB	751.5 (911)	884.2 (146)	1009.0 (36)	964.3 (8)	4.51 (959)	5.29 (152)	5.59 (46)	5.38 (8)

[a] BAB = Branch-antlered bull, branch-antlered yearling bulls selectively shot, "spike" bulls protected. Few branch-antlered yearling bulls survive to breed or be harvested at older ages. BTB = Brow-tined bull, essentially all yearling bulls legally protected. Most branch-antlered yearling bulls survive to breed and be harvested at older ages.

[b] Means significantly different between season types, all $P < 0.04$.

[c] Mean (sample size).

Antlerless/Either Sex Permits

Some hunters were concerned that either-sex permitees shot too many bulls, reducing bulls available to hunters with only the general license. Also, they believed that MFWP would more likely reach their goal of greater antlerless kill if permit holders were restricted to shooting antlerless elk. In response to this concern, the FWP Commission changed regulations effective with the 1991 hunting season, restricting holders of permits to shooting an antlerless elk within the hunting district for which the permit was valid. They could still shoot a bull using their general elk license in other hunting districts. Prior to the regulation change (1986-1990), antlerless (either-sex) permitees shot an average of 11.3% of the total bulls harvested in the Gravelly-Snowcrest hunting districts (Table 11.4). Because they could shoot any legal elk anywhere in the Gravelly-Snowcrest

Mountains, no kills were recorded as illegal. After the regulation change (1991-1995), holders of antlerless permits shot a higher proportion (15.5%) of the total bull kill than before the change ($\chi^2_1 = 25.8$, $P < 0.000$, Table 11.4). The majority of these (86.8%) were legally shot, or reported shot, in a different hunting district than where the antlerless permit was valid but within the Gravelly-Snowcrest Mountains. An average of 13.2% was self-reported as illegally killed within the hunting unit for which the antlerless permit was valid. Even after these illegal kills were deducted, antlerless permit holders still shot a higher proportion of the total bulls harvested after the regulation change (13.5%) than before (11.3%). An increase in the number (and possibly proportion) of bulls harvested by permit holders could at least partially be related to increased numbers of permits issued. However, increased proportions of harvest of bulls by antlerless permit holders were not related to increased numbers of permits issue during 1986-1992, thus the impact of increased numbers of permits during 1993-1995 is questionable. Regardless, prohibiting antlerless permit holders from shooting a bull in the hunting district where they held their permit did not reduce bull kill by permit holders. Starting with year 2000 hunting season the regulation for antlerless permits reverted back to pre-1991 language.

Archery

Based on data from the statewide hunter questionnaire, during 1988-1995 archers harvested 7.5% of the total bulls shot in Gravelly-Snowcrest hunting units or 8.5% of the general season total. For antlerless elk, the harvest by archers was 0.8% of the total and general season harvest. Non-residents harvested 41.4% of the archery bull kill and 3.7% of the archery antlerless elk kill. Telemetry data indicated that within Montana, for bulls, archery harvest was 7.3% of the general season harvest and 6.8% of total harvest. For cows, archery harvest was 2.7% of general season and total harvest. These figures are very close to those from the SWHQ. At this time, archery harvest is a relatively minor component of total harvest.

Wounding loss for archery was 50% of the retrieved kill as determined by telemetry for bulls (4 wounded and died/8 retrieved) and cows (1 wounded and died/2 retrieved). This compared to a wounding loss rate of 8.2% (9/110) for bulls and 19.2% (14/73) for cows during the general rifle season. Although rates of wounding loss were much higher for archery than for rifle hunting, numbers of elk wounded and lost were much higher for rifle hunting because of numbers of hunters and harvest. Calculations indicated that 2.02 times as many bulls were lost through rifle wounding loss than archery wounding loss. For cows, 476 times as many were lost to wounding by rifle hunting as archery hunting. Similar to this area, only small samples were available in other areas. Wounding loss as a percent of retrieved kill for archery was 20% (1/10) for bulls and 60% (3/5) for cows in Colorado (Freddy 2000) and 75% (3/4) for bulls and 100% (2/2) for cows in the Elkhorn Mountains of Montana (DeSimone and Vore 1992). Wounding loss as a percent of retrieved kill for rifle hunting in these areas was 15.9% (10/63) for bulls and 32.3% (20/62) for cows in Colorado and 10.6% (9/85) for bulls and 6.9% (2/29) for cows in the

Table 11.4. Bull elk kill in the Gravelly-Snowcrest Mountains compared between years when hunters could shoot a legal bull anywhere and when they could not shoot a bull in the HD where they held an antlerless permit.

	Years when antlerless permit holders could shoot a bull in any hunting district					
	1986	1987	1988	1989	1990	Total
Total Bulls Killed	573	661	701	597	505	3037
No. by antlerless permit holders	70	81	76	62	55	344
% by antlerless permit holders	12.2	12.3	10.8	10.4	10.9	11.3
Number of Antlerless Permits	1500	1500	1750	1850	1900	
% success	46.3	51.5	57.4	48.9	40.1	
% Self-report of Illegal Kill						
of total bull harvest	0	0	0	0	0	0
of bull kill by permit holders	0	0	0	0	0	0
	Years when permit holders could not shoot a bull within permitted HD					
	1991	1992	1993	1994	1995	Total
Total Bulls Killed	1037	801	663	1256	635	4392
No. by antlerless permit holders	89	95	115	244	136	679
% by antlerless permit holders	8.6	11.9	17.4	19.4	21.4	15.5
Number of Antlerless Permits	1900	2425	3540	3540	4098	
% success	68.2	53.2	34.3	55.5	28.7	
% Self-report of Illegal Kill						
of total bull harvest	1.4	1.0	3.0	1.9	2.8	2.0
of bull kill by permit holders	16.9	8.4	17.4	9.8	13.2	13.2

Elkhorn Mountains. The generally higher wounding loss rates for cows than bulls indicated a greater effort by hunters to follow up on wounded bulls. Combined data for the 2 Montana locations, Colorado, and Idaho (Unsworth and Kuck 1991) indicated archery wounding loss as a percent of retrieved kill of 54.2 percent for bulls (13 wounded and died/24 retrieved) and 66.7 percent for cows (6 wounded and died/9 retrieved). For rifle hunting, wounding loss as a percent of retrieved kill was 11.7 percent for bulls (35 wounded and died/300 retrieved) and 22.0 percent for cows (36 wounded and died/ 164 retrieved). Earlier reports (MFWP 1989, Cada 1991) indicated that Montana archery hunters reported hitting 1,735 elk in 1987 and retrieving 850 (49%) of them. Applied to wounding loss figures from the Gravelly-Snowcrest Mountains, this indicated that about half of elk hit but not retrieved by archers recovered from their wound and half died.

The earlier report (MFWP 1989) indicated no discernible effect on elk distribution of closed versus open archery seasons in HD 324. There also was no positive effect of the closed archery season on calf:100 cow ratios (Tables 6.4 and 6.5). Thus, we could find no evidence that archery season caused a disturbance during the rut that affected breeding.

Illegal Kill of Yearling Bulls

In Chapter 7 (Reproduction and Mortality) we indicated that although illegal mortality rate of spike-antlered yearling bulls was lower under BTB regulations than BAB regulations, the difference was not statistically significant. This may have been primarily the result of small sample size during BAB regulations because other results indicated a real increase in survival of spikes (and branch-antlered yearling bulls). Proportionally fewer spikes (and branch-antlered yearlings during BTB years) were reported at check stations as shot and left (Table 7.14), and fewer were reported in the special hunter questionnaire as shot and left (Table 8.4) during years of BTB regulations than BAB regulations. With the exception of the BTWMA, we observed increased numbers and percentages of bulls on the winter range after BTB seasons compared to after BAB seasons (Tables 6.4 and 6.5). Total harvest of bulls was at a plateau during years with BAB seasons but made a sustained increase after implementation of the BTB season (Fig. 8.9). Hunter satisfaction also increased after implementation of the BTB season (Table 8.4). At least part of this increase in satisfaction appeared related to seeing fewer yearling bulls shot and left. The preponderance of evidence indicated that there was less illegal mortality of yearling bulls under the BTB season than the BAB season.

If we assume that the difference in illegal mortality rate of yearling bulls reported in Chapter 7 was accurate (61.7% greater under BAB regulations) and significant, 40 – 118 more spike-antlered yearling bulls may have survived per year under the BTB season. This increased one-year survival as a result of reduction of illegal mortality resulted in increased reported legal mortality in subsequent years. We based these estimates on information presented earlier in Chapter 7. Additional increased survival of yearling bulls occurred because hunters could no longer legally take branch-antlered yearlings. They were legally harvested under BAB regulations, so do not affect total bull harvest calculations after the first year of BTB seasons, other than age at harvest.

The above calculations are only approximate because the total population was growing during the period. Trend counts of the total elk population increased at an average rate of r = 0.086 during 1984-1989 when BAB regulations were in effect. The increase in average trend count from the 1984-1989 period to the 1990-1996 period (BTB) was r = 0.066. During the last 4 years of AB regulations (1977-1980), average annual bull harvest was 744 (Fig. 8.9). During the period of BAB regulations (1981-1989), average annual bull harvest was 682 (Fig. 8.9), an average decrease of 62 bulls/year, or an average annual decline of r = -0.01. This decline in reported average annual bull harvest despite an increasing total population (r = 0.086) was one indication that something was amiss with the BAB season. Annual bull harvest averaged 890 during 1990-1996, a period of BTB regulations (Fig. 8.9). This was an average increased harvest of 208 bulls/year compared to the period of BAB regulations. We increased the average annual bull harvest of the 1981-1989 period (682) by the average trend count growth rate (r = 0.066) between periods for years 1990-1996. We found that annual bull harvest should have increased such that average annual bull harvest for 1990-1996 should have been 888. This was comparable to the average of 890 observed (Fig. 8.9), indicating that bull harvest increased at the same rate as total population growth during the period of BTB regulations. This was an improvement compared to the decline in reported legal bull harvest during the period of BAB regulations despite an increasing total population. During the period of BTB regulations, an average of about 100 bulls may have been added to the annual harvest because of less illegal mortality and 100 because of population growth. These calculations and results relate to reported legal harvest. Total average annual "harvest" of bulls probably did not really decline during 1981-1989, only legal reported harvest. Any increase in bull harvest during 1981-1989 was "hidden" in spikes that were shot and left or shot and taken home and not reported as legal harvest. It seems clear that the BTB season resulted in increased legal harvest of bulls, less "waste of meat", and increased hunter satisfaction when compared to the BAB season.

We note that any restrictive season will result in some illegal mortality. Thus, the BTB regulation did not eliminate illegal mortality of yearling bulls (it averaged about 14%). BTB regulations did not reduce mortality due to hunters mistaking spikes for cows, hunters intentionally shooting yearling bulls, or a certain amount of loss due to ignorance of regulations by hunters new to the area each year. Also, illegal mortality of large branch-antlered yearlings, which were legal to harvest under BAB regulations, increased under BTB regulations. However, the total amount of illegal mortality that occurred under BAB regulations was reduced by implementation of BTB regulations.

Population Control

An objective of MFWP in recent years was to reduce numbers in some sub-populations within the Gravelly-Snowcrest Mountains. For other sub-populations, a stabilization of numbers (zero growth) was the objective. Although population growth may have slowed after 1995 (Fig. 5.1), an overall decline did not occur. Very small declines may have occurred in some herd ranges, but other herd ranges continued to show substantial population increases (Table 5.2, Figs. 5.2, 5.3, 5.15 – 5.18). We also discussed (Chapter 8) the limitations of continuing to increase antlerless permit levels as an effective method of achieving increased antlerless kill. Varying levels of antlerless kill are necessary to obtain zero population growth or a decline in population. Those levels vary with recruitment rate (Table 11.5). These calculations tell us that even with recruitment as low as 25 calves:100 cows, annual adult female mortality of 11% is necessary to achieve zero growth. With recruitment of 55 calves:100 cows, annual mortality of 24% may be necessary to achieve zero growth. This mortality is from all causes, including both natural and hunting losses. Total mortality less than that listed at the appropriate recruitment ratio will result in population increases and mortality greater than listed levels will result in population declines.

Table 11.5. Total annual mortality rate of adult females necessary to achieve population stability (zero growth) at various calf:100 cow ratios at recruitment and at 2 sex ratios of recruited calves.

Sex ratio of recruited calves ♂♂:♀♀	Calves:100 cows recruited			
	25	35	45	55
100:100	0.111	0.149	0.184	0.216
75:100	0.125	0.167	0.205	0.239

We compared annual mortality rates measured by telemetry (during years with relatively large samples) with zero growth rates at the observed recruitment rate during those years (Table 11.6). Those data indicated why the population grew during 1987-1996. In only 3 of 9 years was the observed mortality rate of adult females greater than the observed recruitment rate. The compounded annual differences between the recruitment rate (necessary mortality rate of cows for zero population growth) and observed mortality rate indicated annual growth of up to r = 0.038. The changes in population trend counts over the same period indicated annual growth of r = 0.068. Either measurement could be in error, or more likely, both. The trend count of 1987-1988 was likely lower than average compared to that of 1995-1996 and population growth was not quite as great as r = 0.068. Similarly, mortality rate of cows may not have been quite as high as measured by telemetry and/or calf:100 cow ratios may have been slightly higher than our estimates. Regardless of these relatively minor measurement errors, by either measurement recruitment was higher than mortality during the period. At the average mortality rates we observed for adult females, population growth occurred when more than 42-43 calves:100 cows were recruited at a sex ratio of 100:100 and 36-37 calves:100 cows were recruited at a sex ratio of 75:100. During most years, at recruitment levels we observed and total population level estimated, the antlerless permit system did not harvest enough females to either stabilize or decrease the population.

Table 11.6. Observed recruitment and mortality rates, 1987-1988 through 1995-1996, compared to mortality rates necessary for zero population growth, Gravelly-Snowcrest Mountains.

Year	Observed Calves:100 cows[b]	Zero growth mortality rate for cows		Observed Mortality rate of cows[c]
		Sex ratio of recruited calves[a]		
		100:100	75:100	
1987-88	51.0	0.203	0.226	0.177
1988-89	45.1	0.184	0.205	0.150
1989-90	49.1	0.197	0.219	0.145
1990-91	53.1	0.210	0.233	0.164
1991-92	53.7	0.212	0.235	0.232[d]
1992-93	45.3	0.185	0.206	0.132
1993-94	47.8	0.193	0.215	0.115
1994-95	50.4	0.201	0.224	0.298[d]
1995-96	21.1	0.095	0.108	0.171[d]
Mean 1	46.3	0.187	0.208	0.176
Mean 2[e]				0.173

[a] Males:female.

[b] Average of observed ratios at WCWMA and BTWMA.

[c] Based on telemetry, see Table 6.4.

[d] Observed mortality rate greater than recruitment rate – population decline.

[e] Mean 2 = telemetry sample combined for all years.

Information presented in Chapter 8 indicated that about 2,750 antlerless permits for the entire Gravelly-Snowcrest complex might be about the highest level that was "efficient" in harvesting antlerless elk. Hunter success rates declined substantially above that level. Harvest at this level of permits would not be enough to stabilize or reduce the current population, so we attempted to determine at what population level antlerless harvest from 2,750 permits would produce zero growth. We used 45 calves:100 cows as the recruitment level, both 100:100 and 75:100 as the recruited sex ratio for calves, both 40% and 50% as success ratios for antlerless permits, 12.5% of antlerless harvest as calves, and 38 bulls:100 cows preseason in our calculations. We also included wounding and natural loss in our calculations. Those calculations produced estimated total antlerless mortality as a number. We then used this number and the other ratios to calculate appropriate preseason elk numbers that would be stabilized by the calculated mortality/harvest. We then converted these preseason numbers to postseason numbers (minus mortality) that would be observed on high efficiency (80% observability) and low efficiency (60% observability) surveys. These calculations indicated that at 45 calves:100 cows recruited, a 50% hunter success ratio, and a recruitment sex ratio of 100:100, 2,750 antlerless permits would reduce the population only when postseason trend counts were below 7,845 during good survey conditions (80% observability) and 5,884 during years with poor (60% observability) survey conditions. At the other extreme of the calculated scenarios (40% hunter success and a recruitment sex ratio of 75 males:100 females), the population would be reduced only when postseason counts were below 5,330 and 3,998 with good and poor survey conditions, respectively. The average postseason trend count for the 8 scenarios calculated was 5,705 elk (6,520 – good survey, 4,890 – poor survey). We used recruitment of 45 calves:100 cows because it was the long-term average. If recruitment was below that level, population reduction could occur at higher postseason counts than those listed. At recruitment above that level, population reduction would occur only if postseason counts were below those listed in the examples.

Thus, at average recruitment, the “efficient” level of antlerless permits (2,750) will only reduce the population when the postseason trend counts are about 700 below the recent highs with the most optimistic (for harvest) assumptions and 2,850 below recent highs at the average of assumptions. For antlerless permits to work as a population control device, the population may have to be reduced by other methods to 700 – 3,000 below current high counts of 8,550. Of course, if recruitment falls, as it has recently, the level of reduction necessary would be less. Some method other than antlerless permits, such as some form of general either-sex harvest, may be necessary to reduce the population to levels where antlerless permits can once again potentially control the population. We also include the caveat that with several years in succession of weather conditions conducive to harvest, reduction could occur with antlerless permits as issued. We did not experience those conditions during the 1990s. Also, if natural mortality rate increases from the levels we observed, hunter harvest might be more effective in controlling elk population numbers. Successful occupation of the Gravelly-Snowcrest Mountains by wolves would likely increase the natural mortality rate of elk above the rate we observed during our study period.

CHAPTER 12

MANAGEMENT IMPLICATIONS

Harvest Management

Bull:100 Cow Ratios

In the low security habitat of the Gravelly-Snowcrest Mountains total bull:100 cow ratios increased during periods of both BAB and BTB regulations compared to AB regulations. However, BTB:100 cow ratios were lower with BAB regulations than AB regulations and were about the same for AB and BTB regulations. We might expect this result because both BAB and BTB seasons concentrate hunting pressure on bulls ≥ 2 years old. Thus BAB hunting seasons increased the number of 2-year-old breeding bulls but did not increase the ratio or number of breeding bulls ≥ 3 years old.

There was substantial annual variation in bull:100 cow ratios with year, regardless of regulation type. When weather during the hunting season was mild, with little snow or cold temperatures, elk were distributed widely, including into Idaho, and at high elevations. Hunting success was lower during those years and post-season bull:100 cow ratios were higher following hunting seasons with mild weather. Conversely, bull:100 cow ratios were lower following hunting seasons with early cold and snowy weather that concentrated elk near winter range at low elevations.

Although weather had a major influence on bull survival during hunting season, the general increasing trend of bull:100 cow ratios throughout the study indicated that BAB and especially BTB regulations resulted in slowly increasing bull:100 cow ratios in this area of low security habitat.

Bull Age

By regulation definition, average age of harvested bulls increased from AB to BAB to BTB regulations. Based on check station data, average age of harvested bulls ≥ 2 years old did not increase for BTB regulations compared to BAB regulations. However, data on number of antler points of harvested bulls from the SWHQ indicated a minor increase in average age of harvested bulls from BAB to BTB regulations. It was likely SWHQ antler point data best represented bull age and that average age did increase slightly. Check station data from weekends and daylight hours likely underrepresented harvest of older bulls. Despite this small, but significant increase in harvest of bulls with ≥ 6 x 6 antlers, the Gravelly-Snowcrest area remained the lowest in the state for percent harvest of bulls with antlers ≥ 6 x 6 points, even after 6 years of BTB regulations.

For the Gallatin-Madison HDs, with higher security habitat conditions than for Gravelly-Snowcrest HDs, the data indicated lower average age of harvested bulls ≥ 2 years old with BAB and BTB regulations compared to AB regulations. Therefore, BAB and BTB regulations apparently put increasing pressure on bulls ≥ 2 years old, reducing their survival and reducing average age. Survival rate, including for yearling bulls, was higher overall in this more secure habitat. Calculated from age structure data, survival of bulls ≥ 2 years old in Gallatin-Madison HDs ranged from S = 0.65 with AB regulations to S = 0.60 with BAB and BTB regulations. Survival of bulls ≥ 2 years old for Gravelly-Snowcrest HDs averaged S = 0.25 for both BAB and BTB regulations. We do not recommend BAB or BTB regulations for areas of secure habitat and where bull age structure is adequate. Where bull survival is 0.50 or more, harvest of yearling bulls apparently results in a reduction in mortality for older bulls.

Bull Age/Calf Production and Survival

We did not find evidence that increasing bull:100 cow ratios in a range from 3 - 21:100 resulted in increased calf:100 cow ratios. Similarly, increasing BTB:100 cow ratios in a range from 0.6 - 5:100 did not result in increased calf:100 cow ratios. For the Flying D area in HD 311, there was no relationship between bull:100 cow ratios of 8 - 77:100 and BTB:100 cow ratios of 2 - 56:100 and calf:100 cow ratios. Calf:100 cow ratios in Gravelly-Snowcrest HDs were higher than in other areas with much higher bull:100 cow and BTB:100 cow ratios. Major changes in calf:100 cow ratios and differences among areas appeared to be related to factors other than numbers and ages of breeding bulls.

Illegal Mortality

Both regulation types with antler point restrictions resulted in illegal mortality. We estimated illegal mortality of yearling bulls to be 25 - 35% of all yearling bulls under BAB regulations. Additionally, legal harvest of about 75% of branch-antlered yearlings occurred. This resulted in estimated total annual mortality of 40% for yearling males. For BTB regulations, estimated total annual mortality of yearling bulls was 14%, all illegal. This decreased mortality resulted in increased survival of yearling bulls and a slight increase in post-season bull:100 cow ratios. In hindsight, the initial BAB regulation in 1981 and 1982 defining a one-inch branch as legal was destined to result in substantial illegal mortality. However, redefinition of a legal branch as 4 inches in length resulted in substantial continuing illegal mortality. Redefining the regulation to emphasize antler form (BTB) rather than number of points or length of points resulted in less illegal mortality.

An initial concern with these regulations was that eliminating hunting mortality of yearlings would result in additional loss to natural mortality of 1- to 2-year-olds. Hunters would never harvest these bulls. We found very little loss to natural mortality. Possibly some loss to emigration might occur if it is not balanced by immigration, but illegal mortality caused the main loss to future hunter bag.

Our evidence for illegal mortality of antlerless elk and legal bulls was limited. If all radiocollared antlerless elk that were shot and not reported were killed by hunters without permits (which was unlikely), the annual rate of illegal mortality would have been 1.4%. Thus, the actual level is probably somewhat below that. For ≥2-year-old bulls, we recorded annual illegal mortality of 0.7%.

Antlers

We found no evidence that protection of spike-antlered yearling bulls and harvesting branch-antlered yearlings resulted in smaller-antlered older bulls. However, our data for bulls ≥ 3 years old was limited. Evidence from other studies suggested that antler characteristics of yearling bulls were primarily determined by condition of the mother and birth date (early birth, larger antlers). Heritability of antler characteristics was highest for older bulls. Thus, attempted genetic manipulation of antler characteristics by regulation would have most likelihood of success if directed toward protection of large antlered older bulls.

Because of environmental characteristics and perhaps genetic factors, the Gravelly-Snowcrest HDs have the potential to produce trophy-quality bull elk. Some of the bull elk with the highest Boone and Crockett scores measured in Montana came from the study area in the 1950s and 1960s. For their age, bulls in the Gravelly-Snowcrest HDs have larger antlers than elk measured from other areas. Today, few bulls in the Gravelly-Snowcrest Mountains live to an age where antler potential is fully expressed. Currently, of 1000 yearling bulls, only 13.4 reach age 5 and 4.5 reach an age older than 5 years old. Information from this area and others indicated that bulls must reach 5 years of age before the antlers of a substantial portion measure ≥ 300 Boone and Crockett points.

The desire of most hunters and MFWP at this time is to produce maximum recreation and harvest of meat from this area. That objective is being achieved well, perhaps better than anywhere in Montana on a per unit of area basis. Should production of trophy bulls ever become an objective for Gravelly-Snowcrest HDs, it will only be achieved by limited entry hunting, similar to that in the Missouri River Breaks. A 50% reduction in hunter numbers in the mid-1980s did not produce an increase in age of harvested bulls.
A substantial reduction in hunter opportunity (perhaps 85%, 6,500-7,000 bull hunters) would be necessary to manage this area for “trophy bulls”.

Hunter Satisfaction

Dissatisfaction with the AB regulation and low bull:100 cow ratios led to the change to BAB regulations. After 8 years, more than half of hunters had positive attitudes about the BAB regulation, but dissatisfaction had increased significantly. Much of this dissatisfaction was the result of observations of spike bulls shot and left in the field. As of 1994, hunter satisfaction with the BTB regulation in the Gravelly-Snowcrest Mountains was high (81%). General hunter satisfaction is high in this area for several reasons. Because there is a high total elk population and relatively open terrain, hunters usually see many elk during their hunt. Compared to past years, they also see relatively high numbers of legal bulls, at least early in the season. Also, it is an area where non-residents and other new hunters have a reasonable chance of success compared to “back country” areas. At this time, the BTB regulation provides substantial hunter harvest, recreation and hunter satisfaction for the Gravelly-Snowcrest area, especially as part of a diverse statewide package of opportunities.

General Bull Management Considerations

Because of the wide areas over which bulls move, bull management must be on a landscape scale, including the entire GLAA and parts of Idaho. Regulation changes that affect only smaller portions of the area, such as those of the 1980s, are not likely to produce measurable increases of the bull population and are more likely to increase illegal mortality. Coordination of seasons with adjacent HDs should occur. For example, a BTB regulation in the Gravelly-Snowcrest HDs adjacent to Idaho areas with spikes legal and BTB on permits, results in harvests of the bulls intended to be "protected" by each regulation because some bulls are subject to both regulations during autumn.

We do not recommend the BAB regulation or specific antler point restrictions such as 4, 5, or 6 point restrictions. All of these produce substantial illegal mortality wherever they have been tried. Further, in areas of secure habitat where a diverse bull age structure exists, BAB and BTB regulations may actually reduce the average age of bulls harvested over time. This occurs because increased hunting pressure than previously is placed on the older bulls and illegal mortality of younger bulls reduces recruitment into older age classes. We should be able to further test the effects of regulation change in secure habitat because many of the more secure hunting districts have recently been changed from AB to BTB regulations (HDs 100, 101, 102, 120, 121, 122, 123, 140, 141, 150, 151, 200, and 202, see Table 11.2 for data prior to change). Data on ages from check stations prior to and after the change will be necessary for these tests.

Production of older, larger bulls is most easily achieved by Limited Entry hunting (limited permits). However, these regulations result in substantial reductions in hunter opportunity. For some areas of low security habitat with high hunting mortality of bulls, the BTB regulation is a reasonable compromise to increase numbers of 2- and 3-year-old bulls. It provides unlimited hunter opportunity, but harvest is almost entirely 2- and 3-year-old bulls. However, post-season and breeding bull:100 cow ratios are maintained at higher levels than occurs for AB hunting in these areas. A tradeoff is that some degree of illegal mortality (14% in the Gravelly-Snowcrest Mountains) occurs, which reduces recruitment of young bulls and does not promote the best image of hunting.

Antlerless Management

Although certain aspects of antlerless management can be at the landscape level, the more discrete herd ranges of cow elk lend themselves to herd range/hunting district management. Hunting districts currently defined for the Gravelly-Snowcrest Mountains provide relatively good boundaries for management of antlerless elk by wintering population/herd range. Some refinements could be made relative to HD 327 and HD 361, which are primarily spring/summer/autumn range. Elk using the eastern portion of HD 327 during spring/summer/autumn are primarily elk wintering on the WCWMA. Those using the central portion of HD 327 primarily winter on the BTWMA and RLWMA. Elk using the western portion of HD 327 are associated with the Basin-Sage Creek winter range in HD 325. If desired, boundaries might be redrawn to eliminate HD 327, incorporating portions into HDs 323, 324, and 325. However, if easily definable boundaries for hunters can not be drawn, the existing HD definitions work reasonably well. Similarly, many elk spending spring/summer/autumn in HD 361 spend winter on the WCWMA and HD 361 could be incorporated into HD 323. However, an unknown portion of the elk in HD 361 during summer is in HDs 310 and 362 during winter. Therefore, incorporating HD 361 into HD 323 might create as many problems as it solved. Nevertheless, management of elk wintering on the WCWMA must consider harvest levels in HD 361 as part of a management strategy.

A more intractable management problem occurs for the Basin-Sage Creek (BS) wintering population. During much of the hunting season, 35-65% of these elk are in Idaho. Harvests of antlerless elk in Idaho are relatively small. These circumstances have resulted in near-maximal growth rates for the BS population, which also is subject to low harvest rates in Montana during mild to average autumns. To reduce this population, either higher harvest must occur in Idaho or Montana must have later season closing dates for the western portion of HD 327 and southern portion of HD 325, or both.

Very high numbers of antlerless permits have been issued in recent years but success rates have declined, especially during years with mild weather. Population levels have not declined substantially in any areas, though population growth may have been reduced to near zero for elk wintering in HDs 324 and 330. Populations wintering on Basin-Sage Creek and the WCWMA have continued to grow. A possible solution for these areas is to implement an antlerless quota regulation where the hunting season is open to general either sex hunting until a quota of antlerless elk coming through check stations is reached. Compared to an open period of either-sex hunting, this would give hunters a more secure feeling that some control of harvest level is maintained. It allows anyone with an elk license the choice of harvesting an antlerless elk when the opportunity presents itself. With limited antlerless permits, the right person is not always in the right place at the right time. Compared to a 3-day or 8-day either-sex season, the quota regulation may maintain pressure on the antlerless segment throughout the season, especially during mild weather years. Drawbacks of the quota regulation are that it is administratively more complex, expensive, and demanding of MFWP employee time. A more substantial check station presence than currently occurs would have to be maintained.

Wounding Loss

Our data suggested that wounding loss, especially of antlerless elk, may be higher than many realize. To account for wounding loss of adult females in population modeling for the Gravelly-Snowcrest Mountains, we were required to multiply the kill reported on the SWHQ by 0.20-0.24 to obtain a numerical estimate. This figure will vary by area, but there was some evidence to suggest that it may be higher in more dense cover. For bulls, wounding loss was 0.10 times the kill reported on the SWHQ. These losses are high enough that it will be necessary to estimate and include wounding loss in any population calculations by biologists.

Habitat Management

The Gravelly-Snowcrest HDs are a cover deficient area for elk; only HD 323 meets the minimal cover/roads requirements proposed by the Hillis Paradigm (Hillis et al. 1991). This results in high harvest rates for both bulls and antlerless elk compared to most other Montana areas. The high harvest rate for bulls led MFWP to recommend season changes from AB to BAB to BTB regulations. This change did not reduce the harvest rate for legally defined bulls, it only reduced the number of bulls defined as legal to harvest. These definitions only delayed mortality by one year and additionally, have resulted in losses to illegal mortality. Temporary reductions of hunter numbers by about 50% coincident to changing the regulation to BAB did not result in a substantial lowering of the harvest rate for legally defined bulls. We estimate that a minimal reduction of hunters by 85% (approximately 7,000 hunters) accomplished by Limited Entry hunting would be necessary to decrease harvest rate of bulls. This reduction is unacceptable at this time. If reduction in harvest rate of bulls becomes desirable, habitat/access management options should be explored. Cooperation of land management agencies such as USFS, BLM, and Montana DNR –SL will be necessary. The challenge of these options will be to reduce (or not increase) harvest of bulls while maintaining high harvests of antlerless elk.

Timber Management

For purposes of bull elk management, no timber harvests are justified. Our data clearly showed that elk surviving during hunting season disproportionately used timbered areas distant from roads. Conversely, harvested elk were disproportionately associated with open habitat close to roads. Any reduction in timber cover in the Gravelly-Snowcrest area will increase harvest rate of elk. Because of the long growing cycle here, areas that are logged take many decades to return to conditions that provide cover for elk during the hunting season. Currently, cover/forage ratios are 11/89 percent for the GLAA and 27/73 percent for USFS ownership. These figures are minimal for cover because all the areas defined as timber cover for our analysis do not provide security cover for elk during the hunting season. Security cover for elk during hunting season is already below minimum standards and timber harvest is not necessary to provide forage for elk.

All mature timber types were important to elk for hiding cover during the hunting season. Also, juvenile lodgepole pine stands were important to antlerless elk and mature lodgepole pine stands were especially important to bulls. Thus, the most commercially important stands for logging were the stands most necessary to elk as hiding cover.

Road Management

Responses to our hunter questionnaires indicated that most unsolicited hunter comments were about issues dealing with roads, access, and ATVs. Hunters were relatively evenly split on these issues, some wanting more and some less roads, access, and use by ATVs. This is not an easy issue to address because goals for harvest of bulls and antlerless elk differ. Increased access, in whatever form, could increase the harvest rate of bulls, which is undesirable. Conversely, increased access might increase antlerless harvest, which is desirable at current population levels.

The Gravelly Mountain area with relatively gentle terrain and open habitat provided almost unlimited vehicular hunter access in the past. A study by Basile and Lonner (1979) on a small portion of the area in 1970-1973 indicated that closing roads reduced elk movements out of the area and spread kill more evenly throughout the hunting season. Over the years, many roads and trails (often self-made by hunters) have been closed. Currently, in addition to closure of individual roads and trails, three large area closures exist on the study area; the Wall Creek area closure, the upper Elk River area closure, and the west half of the Snowcrest Range. However, one frustration that many hunters voiced was that effective enforcement of road closures was lacking and that off-road use by ATVs and snowmobiles was a major problem. The widespread ownership of ATVs and snowmobiles as well as the desire for increased antlerless harvest makes banning of their use problematic.

Effective and rigorous enforcement of existing travel restrictions will be necessary to reduce pressure on bulls and provide for ethical hunting. However, further closure of roads and trails would likely reduce antlerless kill. Restriction of the use of ATVs and snowmobiles to game retrieval only and during only certain hours (such as between 1000-1400 hrs), might be an option worth considering. To some extent, this would make enforcement somewhat easier. Use of ATVs and snowmobiles for purposes other than retrieval and at other times would be an unquestionable violation under this proposal, regardless of whether they were off trails and roads or not. Allowing use of these machines for retrieval would help maintain hunting pressure on antlerless elk.

Calving Areas

Phillips and Aldredge (2000) indicated that regular disturbance of cow elk by humans during the calving period in Colorado (19 May – 19 June) resulted in lower proportions of surviving calves on an experimental area compared to a control area with no disturbance. This finding makes it important to identify calving areas and provide them some measure of protection from disturbance during the calving period.

To some extent, calving areas are widespread in the Gravelly-Snowcrest Mountains (Fig. 10.1). However, there were areas where calving is concentrated (Fig. 10.1). Many of these areas are protected by travel restrictions to 1 July. Several important areas do not currently have protection, however. These include the West Fork of the Madison from Freezeout Creek to Patchtop Mountain, Antelope Basin from Poison Creek to Lone Tree Pass, and the Middle and South Forks of Warmsprings Creeks. As discussed in the Chapter 10, important habitat types in these areas are sagebrush grassland and aspen.

Techniques

Blood Parameters

We found no evidence to support use of whole blood or serum parameters as measures of population condition. Perhaps this was true because elk condition varied little over the course of the study. Values may be useful for comparisons among populations, but we did not have information to do this. We did establish “normal” hematological values for various ages of elk captured by 3 techniques at various times of the year. We also established that time of year, age, and capture technique must all be considered as covariates when comparing blood values among years or areas. Hematological samples were useful for disease monitoring and for determination of pregnancy rates.

Allantoin:Creatinine Ratios

Garrott et al (1996) and Pils et al. (1999) established the potential of allantoin:creatinine ratios from snow-urine samples collected from free-ranging elk populations to measure nutritional value of recently consumed forage. We believe their findings represent a potentially valuable index to annual nutritional status of elk populations over winter. We recommend further investigation of this technique, including establishing ranges of values over a variety of winter conditions for important Montana elk populations and winter ranges.

Diastema Length

We did not find diastema length of elk calves to vary significantly over the course of the study. Usefulness of diastema length as a condition indicator may be limited to comparisons among populations with widely different nutritional conditions or within populations for which nutritional conditions vary widely among years. Our baseline values for a population in generally good condition may be useful for comparison with other populations.

Aging

If determination of ages specific to year for elk ≥3 years is required for decisions or conclusions, aging by use of incisor cementum is required (Hamlin et al. 2000). We recommend use of eruption-wear only for aging elk ≤2 years old.

Ages of hunter-killed elk likely do not represent standing age structure. Our evidence suggested that both hunter selection and behavioral vulnerability by age might affect age-specific hunting mortality rates. Others (Freddy 2000) reached similar conclusions. If standing age structure is necessary for some population calculations or models, some measure of correction for hunter selection/vulnerability will be necessary. We have provided those figures for the Gravelly-Snowcrest population applicable to conditions at the time of this study.

Ages collected at check stations run only during daylight hours on weekends may not representatively sample the oldest bull elk. These bulls are often shot higher in elevation and further from roads than younger bulls and are disproportionately likely to be removed from the area after dark and on weekdays. Ages from check stations may be comparable among years, but likely under sample older bulls.

Similar to deer fawns (Hamlin and Mackie 1989), elk calves were substantially under-reported in the SWHQ compared to the proportions observed at check stations. For modeling and population calculations, biologists will need to apply a correction factor based on check station proportions. Unfortunately, we could determine no consistent correction factor to reassign sex/age categories. We used annual corrections based on check station data.

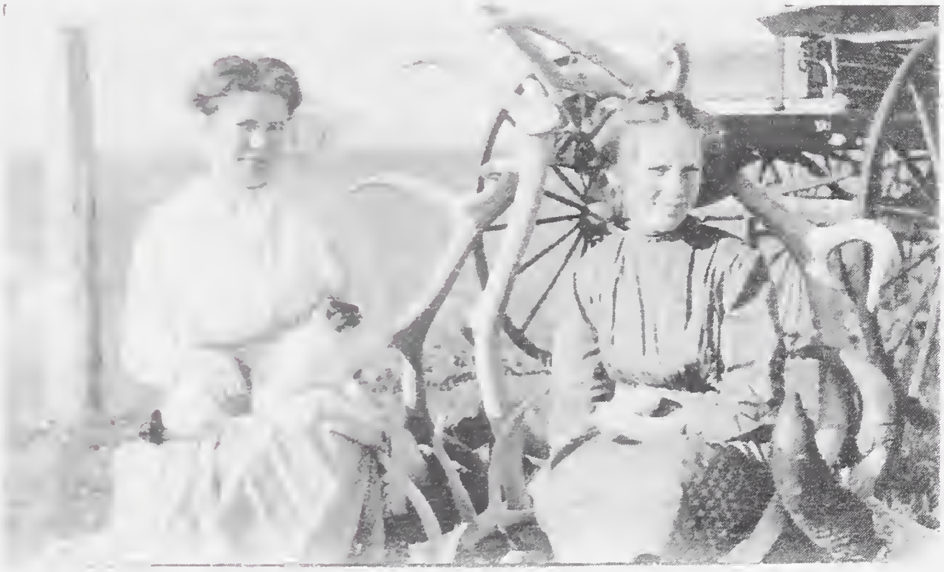
Aerial Trend Counts

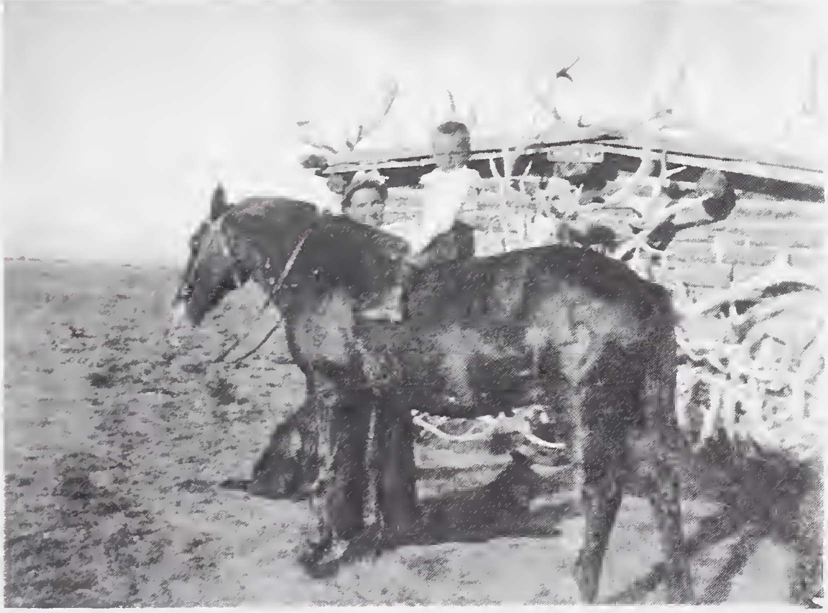
Our aerial trend counts appeared to accurately represent population trend over time periods ≥ 5 years. Further, total population estimates derived from these trend counts seemed to be relatively accurate because they reconciled with mortality estimates from telemetry, sex/age classifications, corrected age structures, and harvest estimates. The trend counts for this migratory population occupying open winter ranges were within a range of 60-80% (sometimes slightly higher) of the estimated "true" population numbers. For some biologists, it will seem unlikely that we miss 40% or even 20% of elk on our trend counts of these open winter ranges. However, for similar winter range conditions on the Northern Yellowstone range, calculations from information provided by Singer et al. (1997) indicated that elk counted (single year with poorest conditions excluded) represented 59-83% (mean = 71%) of numbers estimated by sightability models and 67-91% (mean = 78%) of numbers estimated by population reconstruction. These ranges in observability were very similar to our estimates.

As discussed earlier, two major reasons account for the underestimates of numbers by aerial trend counts on these open winter ranges; fewer elk than are present are counted in observed groups and varying proportions of the population are outside the area flown. The first occurs during all years and the latter is especially important during mild winters, when some elk are on transitional range throughout winter. Thus, although population trend appears to be well represented over longer periods by our trend count flights, total population is substantially underestimated, even in areas of open winter ranges. We also reached this conclusion by attempting to reconcile harvest estimates with population data from trend count flights throughout Montana. These harvest reconciliations all generally indicate that the "true" population is a minimum of 20% higher than the trend count, and usually more.

Capture and Handling

The advantages and disadvantages of drive-netting, net-gunning, and chemical immobilization to capture elk relative to costs, logistics, sampling and selection, and safety are relatively well known. Here, we confine our discussion to relative stress effects on elk. Unsuprisingly, our evidence suggested that short duration contact with elk by helicopters and humans was less stressful for elk. Thus, net-gunning, chemical immobilization, and short duration drive-netting were less stressful on elk than "all-day" drive-netting. Chemical immobilization with narcotic drugs probably provided additional stress reduction. Capture objectives must be considered, but long-duration drive-netting at one location should be avoided if possible.





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Appendix Table A1. Blood chemistry and hematology for newborn elk calves, Gravelly-Snowcrest Mountains, 1984-1988.

Variable[a]	*n*	Mean	Minimum	Maximum	Std. Dev.[b]
BUN	68	17.24	8.00	38.00	4.78
TP	68	5.68	3.90	7.50	0.60
ALB	68	2.97	1.70	4.20	0.56
CA	68	11.40	8.80	15.90	1.07
MG	68	2.33	1.40	3.30	0.42
INP	68	10.28	5.90	13.70	1.80
NA	68	139.79	116.00	151.00	7.00
K	68	8.46	2.40	16.60	2.76
ALKPHOS	68	789.62	275.0	2190.00	335.50
TRIG	48	68.58	17.00	172.00	39.45
CPK	0	-	-	-	-
SGOT	6	43.17	35.00	58.00	10.09
GGT	0	-	-	-	-
CREAT	0	-	-	-	-
TBILI	0	-	-	-	-
RBC	69	6.53	4.90	10.30	0.97
MCV	69	49.32	39.00	59.00	4.63
HCT	69	32.12	22.90	49.70	5.44
WBC	69	5.41	2.00	8.20	1.39
HGB	69	10.75	7.50	17.90	2.25
BANDS	69	0.11	0.00	0.80	0.16
SEGS	69	3.10	0.50	6.89	1.31
LYMP	69	2.02	0.68	3.58	0.64
MONO	69	0.05	0.00	0.30	0.06
EOS	69	0.08	0.00	0.58	0.11
BASO	69	0.04	0.00	0.31	0.07
NRBC	60	7.95	0.00	60.00	9.98
GLOB	1	1.90	1.90	1.90	-
CORT	0	-	-	-	-
PLT	0	-	-	-	-
SGPT	0	-	-	-	-
GLU	0	-	-	-	-
CL	0	-	-	-	-
ALB/TP	68	0.53	0.23	0.75	0.11
N/L RATIO	69	1.91	0.43	7.36	1.36

[a] Meaning of abbreviations of blood values are in Appendix B1.

[b] Std. Dev. = Standard Deviation.

Appendix Table A2. Blood chemisty and hematology for 9- to 10-month old elk calves (Feb-Mar capture), Gravelly-Snowcrest Mountains, 1984-1995.

Variable[a]	*n*	Mean	Minimum	Maximum	Std. Dev.[b]
BUN	424	19.87	8.00	41.00	4.99
TP	424	6.59	4.70	8.60	0.48
ALB	424	4.61	2.80	6.00	0.48
CA	424	10.62	7.70	14.50	0.96
MG	181	2.36	1.70	3.30	0.27
INP	424	5.86	1.60	18.50	1.70
NA	181	140.98	95.00	164.00	13.53
K	181	16.25	5.80	38.90	8.46
ALKPHOS	422	153.48	19.00	574.00	63.90
TRIG	110	49.36	18.00	124.00	19.23
CPK	314	1124.77	199.00	5287.00	743.54
SGOT	314	125.83	46.00	464.00	57.32
GGT	314	51.39	5.00	331.00	46.96
CREAT	312	3.28	1.80	4.70	0.57
TBILI	313	0.70	0.00	3.10	0.56
RBC	420	11.15	7.70	14.40	1.47
MCV	420	48.15	40.00	61.00	3.01
HCT	436	54.83	30.00	67.10	4.79
WBC	420	4.22	1.00	8.80	1.45
HGB	419	18.76	12.80	22.10	1.24
BANDS	419	0.03	0.00	0.70	0.07
SEGS	419	1.70	0.04	5.63	1.12
LYMP	419	2.16	0.48	5.20	0.80
MONO	419	0.02	0.00	0.37	0.04
EOS	419	0.30	0.00	2.17	0.30
BASO	419	0.03	0.00	0.31	0.05
NRBC	169	0.04	0.00	2.00	0.22
GLOB	156	1.95	1.10	4.80	0.43
CORT	16	39.73	28.20	63.70	10.03
PLT	166	298.70	26.00	561.00	104.09
SGPT	71	96.97	40.00	158.00	23.30
GLU	71	168.04	81.00	256.00	39.70
CL	71	102.80	95.00	114.00	2.84
ALB/TP	424	0.70	0.45	0.84	0.06
N/L RATIO	419	0.91	0.01	3.51	0.67

[a] Meaning of abbreviations of blood values are in Appendix B1.

[b] Std. Dev. = Standard Deviation.

Appendix Table A3. Blood chemistry and hematology of elk calves captured during December 1992 (7 months old), Gravelly-Snowcrest Mountains.

Variable[a]	*n*	Mean	Minimum	Maximum	Std. Dev.[b]
BUN	25	10.68	5.00	18.00	2.94
TP	25	6.44	5.70	7.50	0.44
ALB	25	3.85	2.30	4.60	0.45
CA	25	10.77	9.40	12.00	0.61
MG	0	-	-	-	-
INP	25	7.12	4.50	8.70	1.06
NA	25	149.76	141.00	158.00	4.68
K	25	10.21	8.10	13.40	1.25
ALKPHOS	25	126.04	66.00	234.00	48.27
TRIG	0	-	-	-	-
CPK	25	328.72	130.00	810.00	205.30
SGOT	25	98.68	41.00	180.00	32.55
GGT	25	37.56	15.00	170.00	33.95
CREAT	25	3.16	2.70	3.90	0.28
TBILI	25	0.28	0.10	0.50	0.15
RBC	23	12.54	9.50	14.70	1.18
MCV	23	44.30	40.00	49.00	3.14
HCT	23	55.07	46.00	62.20	4.41
WBC	23	4.58	3.00	6.90	0.94
HGB	23	17.50	14.30	19.90	1.57
BANDS	23	0.02	0.00	0.14	0.03
SEGS	23	1.01	0.50	3.42	0.60
LYMP	23	3.16	2.01	4.98	0.87
MONO	23	0.03	0.00	0.21	0.05
EOS	23	0.31	0.00	1.06	0.28
BASO	23	0.05	0.00	0.21	0.05
NRBC	0	-	-	-	-
GLOB	0	-	-	-	-
CORT	0	-	-	-	-
PLT	23	358.13	266.00	567.00	73.37
SGPT	0	-	-	-	-
GLU	0	-	-	-	-
CL	0	-	-	-	-
ALB/TP	25	0.60	0.34	0.71	0.07
N/L RATIO	23	0.39	0.10	1.65	0.32

[a] Meaning of abbreviations of blood values are in Appendix B1.

[b] Std. Dev. = Standard Deviation.

Appendix Table A4. Blood chemistry and hematology for 9- to 10-month old female elk calves, Gravelly-Snowcrest Mountains, 1984-1995.

Variable[a]	*n*	Mean	Minimum	Maximum	Std. Dev.[b]
BUN	212	20.53	9.00	41.00	5.13
TP	212	6.59	5.10	8.60	0.45
ALB	212	4.65	3.50	6.00	0.47
CA	212	10.64	8.50	14.50	1.04
MG	73	2.36	1.90	3.30	0.27
INP	212	6.11	1.60	18.50	1.86
NA	73	143.23	95.00	164.00	14.87
K	73	16.15	5.90	38.90	9.00
ALKPHOS	210	152.89	19.00	454.00	61.78
TRIG	65	51.12	18.00	124.00	20.17
CPK	147	1217.68	209.00	3663.00	755.84
SGOT	147	127.41	46.00	421.00	59.79
GGT	147	43.53	5.00	331.00	38.89
CREAT	146	3.45	2.30	4.60	0.45
TBILI	147	0.82	0.00	2.40	0.54
RBC	205	10.86	7.70	13.90	1.41
MCV	205	49.04	42.00	58.00	2.74
HCT	214	54.65	30.00	67.10	5.08
WBC	205	4.48	1.20	8.80	1.44
HGB	204	18.90	12.80	22.10	1.21
BANDS	205	0.04	0.00	0.70	0.09
SEGS	205	2.00	0.26	5.63	1.11
LYMP	205	2.12	0.67	5.20	0.73
MONO	205	0.02	0.00	0.37	0.05
EOS	205	0.29	0.00	2.17	0.31
BASO	205	0.03	0.00	0.31	0.05
NRBC	78	0.03	0.00	2.00	0.23
GLOB	60	1.89	1.10	4.80	0.50
CORT	9	42.99	28.80	63.70	11.33
PLT	56	275.82	38.00	557.00	99.35
SGPT	8	87.38	40.00	116.00	24.08
GLU	8	161.25	113.00	228.00	37.60
CL	8	103.25	100.00	107.00	1.98
ALB/TP	212	0.71	0.58	0.83	0.05
N/L RATIO	205	1.07	0.05	3.51	0.66

[a] Meaning of abbreviations of blood values are in Appendix B1.

[b] Std. Dev. = Standard Deviation.

Appendix Table A5. Blood chemistry and hematology for 1-year-old female elk (Feb-Mar), Gravelly-Snowcrest Mountains, 1984-1995.

Variable[a]	*n*	Mean	Minimum	Maximum	Std. Dev.[b]
BUN	80	19.13	12.00	36.00	5.01
TP	80	6.96	5.30	8.50	0.58
ALB	80	4.75	3.50	5.90	0.46
CA	80	10.76	6.10	13.50	1.32
MG	47	2.43	1.30	3.10	0.35
INP	80	5.57	2.60	9.60	1.48
NA	47	141.85	108.00	162.00	15.16
K	47	18.66	5.60	41.10	10.58
ALKPHOS	80	147.09	46.00	400.00	66.95
TRIG	46	49.72	16.00	134.00	25.87
CPK	34	1000.74	218.00	2500.00	600.40
SGOT	34	104.59	49.00	185.00	36.07
GGT	34	33.62	4.00	62.00	12.98
CREAT	34	3.57	2.60	4.20	0.36
TBILI	34	0.68	0.10	2.00	0.49
RBC	73	10.68	8.00	13.80	1.29
MCV	73	51.33	45.00	60.00	3.27
HCT	80	55.15	45.20	67.30	4.67
WBC	73	5.14	1.80	8.40	1.42
HGB	73	19.46	16.40	22.10	1.18
BANDS	73	0.03	0.00	0.49	0.08
SEGS	73	2.25	0.13	4.66	1.24
LYMP	73	2.43	0.79	5.95	0.87
MONO	73	0.03	0.00	0.21	0.05
EOS	73	0.38	0.06	1.46	0.25
BASO	73	0.03	0.00	0.24	0.05
NRBC	45	0.02	0.00	1.00	0.15
GLOB	11	2.30	1.70	2.90	0.36
CORT	8	60.31	53.60	65.00	4.52
PLT	17	281.82	79.00	372.00	66.63
SGPT	1	70.00	70.00	70.00	-
GLU	1	161.00	161.00	161.00	-
CL	1	115.00	115.00	115.00	-
ALB/TP	80	0.68	0.54	0.82	0.06
N/L RATIO	73	1.07	0.02	3.38	0.70

[a] Meaning of abbreviations of blood values are in Appendix B1.

[b] Std. Dev. = Standard Deviation.

Appendix Table A6. Blood chemistry and hematology for 2-year-old female elk (Feb-Mar), Gravelly-Snowcrest Mountains, 1984-1995.

Variable[a]	*n*	Mean	Minimum	Maximum	Std. Dev.[b]
BUN	42	18.10	9.00	31.00	4.54
TP	42	7.18	4.40	8.60	0.73
ALB	42	4.78	2.90	5.90	0.60
CA	42	11.06	9.00	15.20	1.14
MG	28	2.28	1.40	2.90	0.35
INP	42	5.18	2.70	9.00	1.39
NA	28	143.36	108.00	162.00	13.19
K	28	16.89	8.20	37.60	8.22
ALKPHOS	42	195.45	56.00	847.00	135.33
TRIG	24	51.96	20.00	145.00	31.02
CPK	18	781.72	147.00	2500.00	603.92
SGOT	18	116.94	59.00	196.00	42.33
GGT	18	43.33	15.00	132.00	27.78
CREAT	18	3.63	2.00	4.50	0.57
TBILI	18	0.59	0.00	1.70	0.57
RBC	40	10.46	7.80	12.50	1.32
MCV	40	53.45	45.00	63.00	3.81
HCT	43	55.34	45.60	63.60	4.43
WBC	40	4.90	1.10	7.40	1.63
HGB	40	18.72	15.10	21.90	1.40
BANDS	40	0.03	0.00	0.41	0.08
SEGS	40	2.14	0.18	5.56	1.50
LYMP	40	2.32	0.84	4.40	0.91
MONO	40	0.02	0.00	0.17	0.05
EOS	40	0.36	0.00	1.06	0.25
BASO	40	0.03	0.00	0.24	0.05
NRBC	24	0.00	0.00	0.00	0.00
GLOB	13	2.42	1.80	3.70	0.50
CORT	3	44.03	41.00	47.80	3.46
PLT	8	256.62	239.00	276.00	14.91
SGPT	4	66.25	47.00	95.00	21.50
GLU	4	155.25	119.00	187.00	27.96
CL	4	108.50	102.00	114.00	4.93
ALB/TP	42	0.67	0.39	0.78	0.07
N/L RATIO	40	1.12	0.10	3.67	0.98

[a] Meaning of abbreviations of blood values are in Appendix B1.

[b] Std. Dev. = Standard Deviation.

Appendix Table A7. Blood chemistry and hematology for ≥3-year-old female elk (Feb-Mar), Gravelly-Snowcrest Mountains, 1984-1995.

Variable[a]	*n*	Mean	Minimum	Maximum	Std. Dev.[b]
BUN	209	18.40	8.00	39.00	4.95
TP	209	7.17	3.70	10.40	0.81
ALB	209	4.72	2.30	5.80	0.58
CA	209	10.97	5.80	13.90	1.19
MG	171	2.39	1.30	3.80	0.40
INP	209	5.27	1.50	11.80	1.62
NA	169	142.85	68.00	167.00	16.76
K	169	17.47	6.00	42.70	9.15
ALKPHOS	209	140.56	20.00	557.00	97.40
TRIG	161	50.17	12.00	207.00	25.48
CPK	48	632.08	121.00	1404.00	359.97
SGOT	48	107.06	57.00	371.00	46.73
GGT	48	43.08	5.00	124.00	21.79
CREAT	48	3.48	2.30	4.60	0.56
TBILI	48	0.48	0.00	1.50	0.43
RBC	165	9.82	6.80	12.40	1.06
MCV	165	54.95	48.00	65.00	3.54
HCT	203	53.25	39.00	72.00	5.60
WBC	165	5.17	1.50	11.90	1.83
HGB	165	18.81	14.40	22.30	1.55
BANDS	165	0.08	0.00	1.04	0.18
SEGS	165	2.36	0.35	8.69	1.51
LYMP	165	2.36	0.75	5.83	0.91
MONO	165	0.03	0.00	0.22	0.04
EOS	165	0.35	0.00	2.13	0.28
BASO	165	0.03	0.00	0.29	0.05
NRBC	125	0.01	0.00	1.00	0.09
GLOB	29	2.84	1.90	6.10	0.83
CORT	35	52.49	24.40	76.60	15.23
PLT	17	247.59	18.00	372.00	92.96
SGPT	10	65.80	45.00	95.00	14.75
GLU	10	171.50	115.00	204.00	25.27
CL	10	107.40	101.00	114.00	3.63
ALB/TP	209	0.66	0.28	0.93	0.08
N/L RATIO	165	1.20	0.09	4.66	0.88

[a] Meaning of abbreviations of blood values are in Appendix B1.

[b] Std. Dev. = Standard Deviation.

Appendix Table A8. Blood chemistry and hematology for 1-year-old male elk (Feb-Mar), Gravelly-Snowcrest Mountains, 1984-1995.

Variable[a]	*n*	Mean	Minimum	Maximum	Std. Dev.[b]
BUN	34	20.32	12.00	34.00	4.87
TP	34	6.79	4.10	8.50	0.78
ALB	34	4.41	2.30	5.10	0.55
CA	34	10.89	8.10	13.10	1.01
MG	24	2.37	1.80	3.10	0.29
INP	34	5.34	3.40	7.80	1.14
NA	24	142.04	102.00	161.00	15.41
K	24	18.21	6.10	45.00	10.73
ALKPHOS	34	119.50	27.00	320.00	57.33
TRIG	24	37.00	8.00	59.00	11.69
CPK	10	617.10	141.00	1519.00	424.08
SGOT	10	99.70	61.00	145.00	24.34
GGT	10	46.30	33.00	68.00	9.24
CREAT	10	3.50	3.10	4.00	0.28
TBILI	10	0.57	0.10	1.70	0.52
RBC	29	10.32	8.30	11.90	0.89
MCV	29	50.10	45.00	60.00	3.63
HCT	33	52.26	43.60	63.80	4.71
WBC	29	4.82	2.40	7.40	1.44
HGB	29	19.01	16.60	26.00	1.64
BANDS	29	0.05	0.00	0.44	0.12
SEGS	29	2.13	0.48	4.69	1.16
LYMP	29	2.09	1.39	3.21	0.50
MONO	29	0.02	0.00	0.20	0.05
EOS	29	0.52	0.00	2.12	0.46
BASO	29	0.02	0.00	0.09	0.03
NRBC	21	0.00	0.00	0.00	0.00
GLOB	3	2.53	1.90	2.90	0.55
CORT	4	59.58	55.00	67.00	5.41
PLT	3	291.00	251.00	315.00	34.87
SGPT	0	-	-	-	-
GLU	0	-	-	-	-
CL	0	-	-	-	-
ALB/TP	34	0.65	0.44	0.79	0.08
N/L RATIO	29	1.09	0.27	2.71	0.66

[a] Meaning of abbreviations of blood values are in Appendix B1.

[b] Std. Dev. = Standard Deviation.

Appendix Table B1. Names and units of measurement for abbreviations of blood chemistry and hematology parameters used in report.

Blood Parameter Abbreviation	Units	Full parameter name
BUN	mg/dl	Blood Urea Nitrogen
TP	g/dl	Total Protein
ALB	g/dl	Albumen
ALB/TP	%	Albumen/Total Protein
CA	mg/dl	Calcium
MG	mg/dl	Magnesium
INP	mg/dl	Inorganic Phosphorus
NA	meq/l	Sodium
K	meq/l	Potassium
ALKPHOS	IU/l	Alkaline Phosphatase
TRIG	mg/dl	Triglycerides
CK	IU/l	Creatine kinase
SGOT	IU/l	Aspartate aminotransferase
GGT	IU/l	Gamma glutamyl transferase
CREAT	mg/dl	Creatinine
TBILI	mg/dl	Bilirubin
RBC	$x10^6mm3$	Red Blood Cells
PCV	μm^3	Packed Cell Volume
HCT	%	Hematocrit
WBC	$x10^3mm^3$	White Blood Cells
HGB	g/dl	Hemoglobin
BANDS	$x10^3mm^3$	Banded neutrophil
SEGS	$x10^3mm^3$	Segmented neutrophil
LYMP	$x10^3mm^3$	Lymphocytes
MONO	$x10^3mm^3$	Monocytes
EOS	$x10^3mm^3$	Eosinophil
BASO	$x10^3mm^3$	Basophil
N/L Ratio	%	Neutrophil/Lymphocyte ratio
NRBC	#/100 WBC	Neucleated red blood cells
GLOB	g/dl	Globulin
PLT	$x10^3mm^3$	Platelets
SGPT	IU/l	Alanine aminotransferase
GLU	mg/dl	Glucose
CL	μmol	Chloride

Appendix Table C1. Hunter harvest of elk in Gravelly-Snowcrest hunting districts as reported on the Statewide Hunter Questionnaire[a], 1960-1996.

			Males			Antlerless				
Year	Hunter Residency[b]	Number Hunters	≥ 2 years old	Yearlings	Total	Adult Females	Calves	Total	Grand Total	Antlerless Permits (% success)
1960	R	2971	227	128	355	299	128	427	796	
	NR	390	56	6	62	-	-	-	62	
	Total	3360	283	134	417	299	128	427	858	
1961	R	2635	230	138	368	291	46	337	705	
	NR	460	105	7	112	14	7	21	132	
	Total	3095	334	145	479	305	53	358	837	
1962	R	4244	229	86	315	331	272	603	1118	
	NR	838	55	39	94	141	71	212	306	
	Total	5082	284	125	409	672	343	1015	1424	
1963	R	2245	121	-	-	-	-	-	121	
	NR	579	66	-	-	-	-	-	66	
	Total	2824	188	-	-	-	-	-	188	
1964	R	1495	114	46	160	-	-	-	162	
	NR	572	55	35	90	-	-	-	72	
	Total	2068	168	82	250	-	-	-	255	

[a] Harvest survey techniques and questions varied by year, some data not available in some years. Numbers in individual categories may not add up to totals because of separate samples and rounding. Hunting districts include HD 322 to make recent years comparable to pre-1967 years (Hds 322, 323, 324, 325, 326, 327, 330).

[b] R = Resident, NR = Non-resident.

[c] No. permit holders that hunted (% success).

Appendix Table C1 . (continued).

			Males			Antlerless				
Year	Hunter Residency[a]	Number Hunters	≥ 2 years old	Yearlings	Total	Adult Females	Calves	Total	Grand Total	Antlerless Permits (% success)
1965	R	920	100	-	100	-	-	-	100	
	NR	315	85	-	85	-	-	-	85	
	Total	1235	185	-	185	-	-	-	185	
1966	R	1378	169	113	282	11	0	11	294	
	NR	243	49	0	49	0	0	0	49	
	Total	1621	218	113	331	11	0	11	342	
1967	R	2735	280	223	503	142	14	156	662	
	NR	209	?	?	?	14	0	14	?	
	Total	2944	280	223	503	156	14	170	676	125 (136%)[c]
1968	R	3012	289	270	559	237	34	271	836	
	NR	409	69	14	83	55	14	69	150	
	Total	3421	356	283	639	292	48	340	987	470 (72.3)
1969	R	4195	238	304	542	336	71	407	957	
	NR	669	134?	?	134?	?	?	?	134?	
	Total	4861	372?	304?	676?	336?	71?	407?	1091?	700 (58.1)
1970	R	5686	251	502	753	-	-	-	-	
	NR	778	59	41	100	-	-	-	-	
	Total	6464	310	543	853	291	34	325	1178	685 (47.5)

[a] Harvest survey techniques and questions varied by year, some data not available in some years. Numbers in individual categories may not add up to totals because of separate samples and rounding. Hunting districts include HD 322 to make recent years comparable to pre-1967 years (Hds 322, 323, 324, 325, 326, 327, 330).

[b] R = Resident, NR = Non-resident.

[c] No. permit holders that hunted (% success).

Appendix Table C1. (continued).

			Males			Antlerless				
Year	Hunter Residency[a]	Number Hunters	≥ 2 years old	Yearlings	Total	Adult Females	Calves	Total	Grand Total	Antlerless Permits (% success)
1971	R	4555	134	307	441	-	-	-	-	
	NR	1433	72	80	152	-	-	-	-	
	Total	5988	206	387	593	196	28	224	817	590 (38.0)
1972	R	4824	102	207	309	168	57	225	504	
	NR	1369	38	71	109	21	3	24	128	
	Total	6193	140	278	418	189	60	249	632	599 (41.6)
1973	R	4355	133	227	360	156	32	188	518	
	NR	1635	36	78	114	15	2	17	127	
	Total	5990	169	305	474	171	34	205	645	433 (47.3)
1974	R	5082	112	224	336	78	17	95	486	
	NR	1190	55	69	124	14	0	14	146	
	Total	6272	167	293	460	92	17	109	632	274 (39.8)
1975	R	5115	127	261	388	127	17	144	588	
	NR	1594	44	108	152	7	1	8	170	
	Total	6709	171	369	540	134	18	152	758	279 (54.5)
1976	R	4710	93	240	333	123	23	146	490	
	NR	1184	49	74	123	15	2	17	139	
	Total	5894	142	314	456	138	25	163	629	315 (51.8)

[a] Harvest survey techniques and questions varied by year, some data not available in some years. Numbers in individual categories may not add up to totals because of separate samples and rounding. Hunting districts include HD 322 to make recent years comparable to pre-1967 years (Hds 322, 323, 324, 325, 326, 327, 330).

[b] R = Resident, NR = Non-resident.

[c] No. permit holders that hunted (% success).

Appendix Table C1. (continued).

			Males			Antlerless				
Year	Hunter Residency[a]	Number Hunters	≥ 2 years old	Yearlings	Total	Adult Females	Calves	Total	Grand Total	Antlerless Permits (% success)
1977	R	5898	203	383	586	168	27	195	830	
	NR	1215	98	99	197	16	1	17	228	
	Total	7113	301	482	783	184	28	212	1058	329 (64.4)
1978	R	5805	131	348	479	272	36	308	820	
	NR	1711	66	172	238	30	3	33	278	
	Total	7516	197	520	717	302	39	341	1098	666 (51.2)
1979	R	6371	139	442	581	220	40	260	861	
	NR	1979	43	159	202	26	3	29	245	
	Total	8260	182	601	783	246	43	289	1106	547 (52.8)
1980	R	5363	117	346	463	173	16	189	673	
	NR	1664	48	180	228	22	2	24	255	
	Total	7027	165	526	691	195	18	213	928	410 (52.0)
1981	R	4149	228	209	437	135	18	153	593	
	NR	1376	117	63	180	14	2	16	202	
	Total	5525	345	272	617	149	20	169	795	292 (57.9)
1982	R	4588	337	295	632	314	21	335	975	
	NR	1319	151	88	239	37	4	41	283	
	Total	5907	488	383	871	351	25	376	1258	573 (65.6)

[a] Harvest survey techniques and questions varied by year, some data not available in some years. Numbers in individual categories may not add up to totals because of separate samples and rounding. Hunting districts include HD 322 to make recent years comparable to pre-1967 years (Hds 322, 323, 324, 325, 326, 327, 330).

[b] R = Resident, NR = Non-resident.

[c] No. permit holders that hunted (% success).

Appendix Table C1. (continued).

			Males			Antlerless				
Year	Hunter Residency[a]	Number Hunters	≥ 2 years old	Yearlings	Total	Adult Females	Calves	Total	Grand Total	Antlerless Permits (% success)
1983	R	5311	167	201	368	542	66	608	976	
	NR	1578	127	77	204	54	8	62	266	
	Total	6856	294	278	572	596	74	670	1242	1275 (52.6)
1984	R	4736	173	222	395	607	82	689	1090	
	NR	1775	140	104	244	92	12	104	347	
	Total	6511	313	326	639	699	94	793	1437	1553 (51.1)
1985	R	4397	215	192	407	608	109	717	1126	
	NR	1304	67	92	159	85	13	98	254	
	Total	5701	282	284	566	693	122	815	1380	1803 (45.2)
1986	R	4711			476	447	79	526	1002	
	NR	1286			195	53	10	63	258	
	Total	5996	398	274(137)[d]	672	500	89	589	1261	1272 (46.3)
1987	R	4995			469	526	64	590	1059	
	NR	1558			252	80	3	83	335	
	Total	6553	489	232(49)	721	606	67	673	1394	1307 (51.5)
1988	R	4947			474	696	88	784	1258	
	NR	1549			322	74	10	84	406	
	Total	6496	616	180(71)	796	770	98	868	1664	1513 (57.4)

[a] Harvest survey techniques and questions varied by year, some data not available in some years. Numbers in individual categories may not add up to totals because of separate samples and rounding. Hunting districts include HD 322 to make recent years comparable to pre-1967 years (Hds 322, 323, 324, 325, 326, 327, 330).

[b] R = Resident, NR = Non-resident.

[c] No. permit holders that hunted (% success).

Appendix Table C1. (continued).

			Males			Antlerless				
Year	Hunter Residency[a]	Number Hunters	≥ 2 years old	Yearlings	Total	Adult Females	Calves	Total	Grand Total	Antlerless Permits (% success)
1989	R	5555			464	641	103	744	1208	
	NR	1775			217	79	20	99	316	
	Total	7330	486	195(71)	681	720	123	843	1524	1723 (48.9)
1990	R	5393			357	558	64	622	979	
	NR	1843			193	76	15	91	284	
	Total	7236	531	19(10)	550	634	79	713	1263	1779 (40.1)
1991	R	5320			658	849	144	993	1651	
	NR	2071			422	105	18	123	545	
	Total	7391	1094	76(52)	1080	962	168	1130	2210	1656 (68.2)
1992	R	6124			511	871	119	990	1501	
	NR	1863			224	108	12	120	344	
	Total	7987	789	41(34)	830	984	134	1118	1948	2102 (53.2)
1993	R	6893			407	785	100	885	1292	
	NR	2449			256	108	8	116	372	
	Total	9342	631	32(27)	663	893	108	1001	1664	2919 (34.3)

[a] Harvest survey techniques and questions varied by year, some data not available in some years. Numbers in individual categories may not add up to totals because of separate samples and rounding. Hunting districts include HD 322 to make recent years comparable to pre-1967 years (Hds 322, 323, 324, 325, 326, 327, 330).

[b] R = Resident, NR = Non-resident.

[c] No. permit holders that hunted (% success).

Appendix Table C1. (continued).

1994	R	7787			823	1303	188	1491	2314	
	NR	2511			433	97	23	120	553	
	Total	10298	1210	46(15)	1256	1400	211	1611	2867	2901 (55.5)
1995	R	8160			409	758	79	837	1246	
	NR	2795			226	92	11	103	329	
	Total	10944	606	29(11)	635	850	90	940	1575	3277 (28.7)
1996	R	7409			667	1126	149	1275	1942	
	NR	4107			630	256	86	342	972	
	Total	11516	1267	30(22)	1297	1382	235	1617	2914	3880 (41.7)

[a] Harvest survey techniques and questions varied by year, some data not available in some years. Numbers in individual categories may not add up to totals because of separate samples and rounding. Hunting districts include HD 322 to make recent years comparable to pre-1967 years (Hds 322, 323, 324, 325, 326, 327, 330).

[b] R = Resident, NR = Non-resident.

[c] No. permit holders that hunted (% success).

Appendix Table D1. Names, descriptions, and areas of vegetation/cover types referred to in report.

Vegetation/Cover Type abreviation[a]	Full Name and description of vegetation/cover type	Hectares	% of Area
Aspen	Aspen – mixed with conifer types but treated separately because of importance	4,913	2.6
DFencr	Douglas Fir encroachment (into grassland or sagebrush/grassland)	5,429	2.8
DFGold	Mature Douglas Fir (>80 years, multilayered), DF types lower elevation	28,264	14.7
DFinf	Infant Douglas Fir (seedling to sapling size, 1-20 years)	2,906	1.5
DFjuv	Juvenile Douglas Fir(uniform pole size stands, 20-80 years)	544	0.3
Dry Mead	Grass-herb community (usually < 6,800 feet elevation)	7,970	4.2
LPGold	Mature Lodgepole Pine (see DFGold), LP types are mid-elevation	15,121	7.9
LPinf	Infant Lodgepole Pine (see Dfinf)	3,397	1.8
Lpjuv	Juvenile Lodgepole Pine (see Dfjuv)	3,753	2.0
PF	Limber Pine (lower elevations)	1,790	0.9
Rock	Primarily barren mountain peaks, talus	6,615	3.4
SAFencr	Subalpine Fir encroachment (into meadows)	79	Tr
SAFGold	Mature Subalpine Fir (see DFGold), SAF types are higher elevation, > 7,800 feet	9,866	5.1
SAFinfjuv	Infant & juvenile Subalpine Fir (see DFinf & Dfjuv)	1,069	0.6
Sage	Sagebrush-Grassland	63,374	33.0
SGold	Mature Spruce (Engelmann)	3,169	1.7
WB	Whitebark Pine (usually mixed w/ some subalpine fir, high elevation)	23,484	12.2
Wet Mead	Grass-herb community (usually 6,800-9,200 feet elevation)	7,634	4.0
Other		2,779	1.5
TOTAL		192,157	100.00

[a] See Draft (8-30-99) Gravelly Landscape Analysis for more description (USFS, Ennis, Montana).